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ABSTRACT

The need to reinforce the skills of science teachers and supervisors and the need to increase student performance in the sciences have become critical national concerns. The importance of quality science education grows as science and technology continue to be major factors in our daily lives. New York City has recognized the need to enhance science teaching by providing assistance in staff development. This publication was produced to serve as a resource for those involved in upgrading and developing science programs in the schools. Included in this publication are articles addressing the philosophy and methodology of elementary science teaching, exemplary lesson plans, approaches to working with children, activities for students and teachers, information on interrelating reading and science in the classroom, field trips, stimulating science interest, science fairs, a textbook review, evaluation techniques, and a bibliography. Five appendices cover: (1) "What Research Says"; (2) "Parallel and Series Circuits"; (3) "Behavior of Mealworms"; (4) "Can You Find"; and (5) "Lifestyle Survey Form." (RT)

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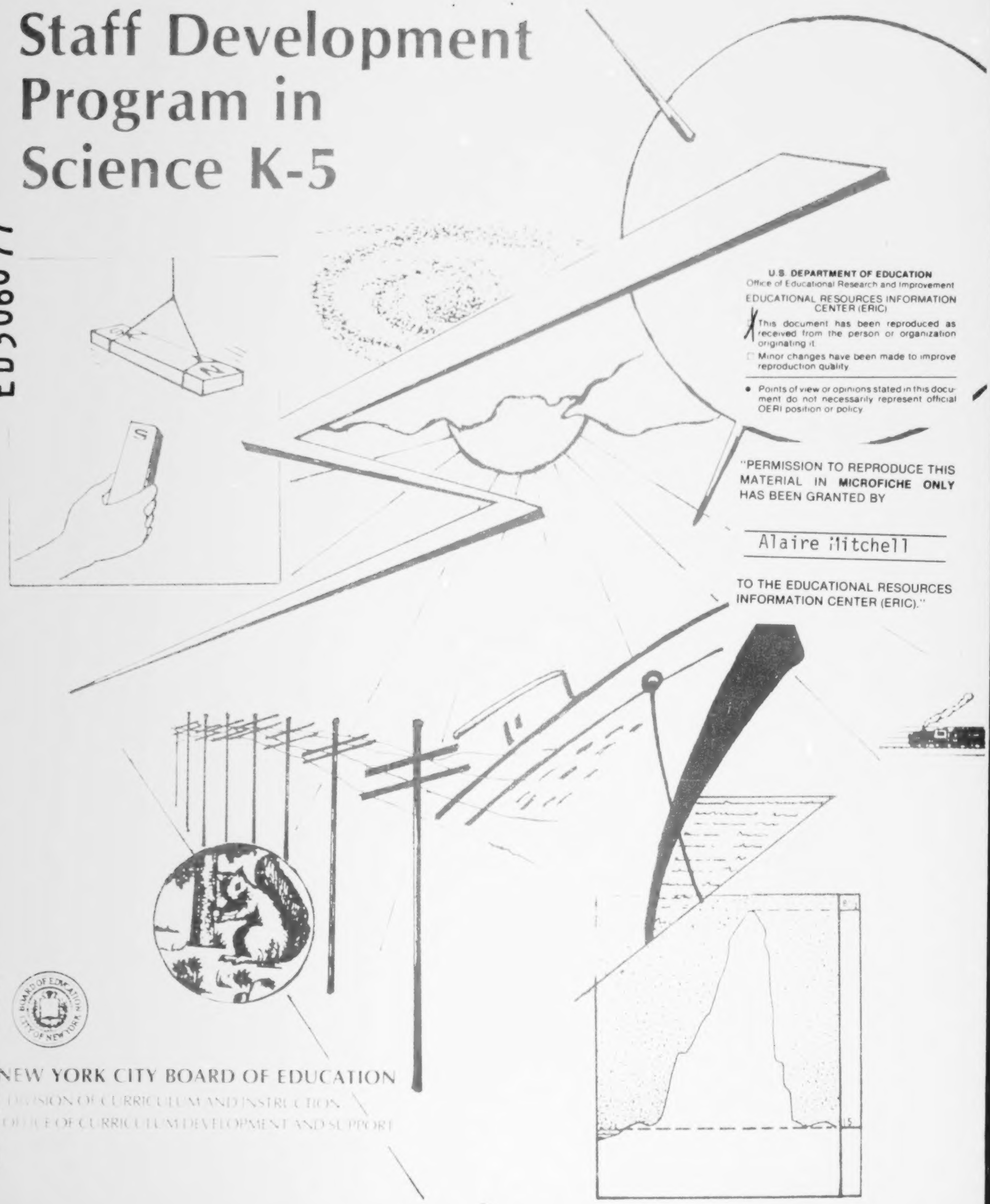

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Staff Development Program in Science K-5

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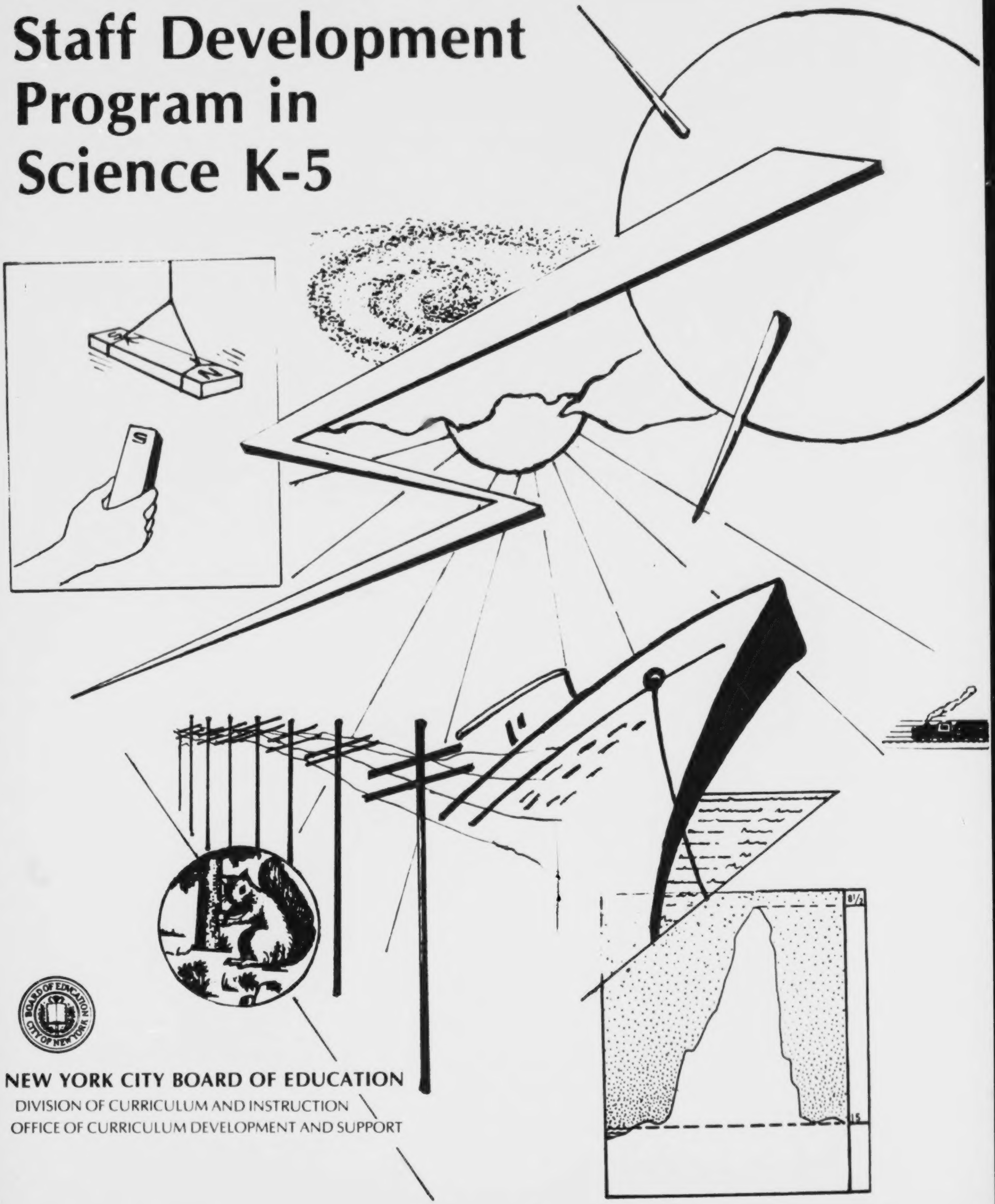

NEW YORK CITY BOARD OF EDUCATION
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FOREWORD

The Science Staff Development Program represents a response to specific needs that have taken on special urgency in recent times: the need to upgrade student performance in the sciences at all levels and the need to sharpen the skills of science teachers and supervisors to reflect the most recent educational research.

The goal of the Science Staff Development Program is to enhance science education in the New York City public schools. Teachers and supervisors will become familiar with the latest theories and ideas prevalent in teaching and learning science; they will study the methods and techniques which have been proven effective in rendering these theories successful in the classroom; and they will examine the processes by which a science program and an individual science lesson may be evaluated by updated standards.

Both science and science education are critical national concerns. As science and technology continue to touch our daily lives with ever-increasing frequency, the importance of quality science education grows. It is our hope that the Science Staff Development Program will serve as a catalyst for the continuing development of science education in New York City, and will ultimately increase the ability of our students to interact successfully with the modern world.

Charlotte Frank

Charlotte Frank
Executive Director
Division of Curriculum and Instruction

ACKNOWLEDGMENTS

Staff Development Program in Science K-5 is a project of the Division of Curriculum and Instruction, Charlotte Frank, Executive Director. Morris Freedman, Director of the Office of Curriculum Development and Support, provided overall supervision. This guide was developed for use in the 1982 Science Staff Development Program and was revised for the 1984 Science Staff Development Program.

We acknowledge our debt to the City Council, which voted special funds to supplement the New York City Education Budget, thus granting us the opportunity to offer this program for science supervisors and teachers in our city's schools.

Anthony Galitsis, Director, Science Unit, organized the program and was directly involved in the writing and editing of the guide.

Gabrielle Edwards, Assistant Principal, Science, Franklin D. Roosevelt High School, assisted in coordinating the 1982 Science Staff Development Program. Geoffrey N. Schwartz, Assistant Principal, Science, Bayridge High School; and Barry Wiesenfeld, Assistant Principal, Junior High School 158Q, assisted in directing the 1984 Science Staff Development Program.

Rose Blaustein, Science Consultant, was the principal writer of this guide both in 1982 and 1984.

John Holst, Assistant Principal, P.S. 257M, was a contributing writer and editor of both the 1982 guide and this revision.

Elliot Blaustein organized the 1982 guide and served as principal editor of the 1984 revision. Ira Kanis, Curriculum and Instructional Coordinator, Science Unit, assisted in editing and organizing the current edition.

Willard Jacobson, Professor of Science Education, Columbia University, wrote the segment entitled "Approaches to Working with Chidren in Science."

The manuscript was typed by Anna Marie Parasole.

The final editing and Production of this guide were the responsibility of the Editorial Production Unit which is supervised by Alaire Mtichell, Assistant Director of Curriculum Research, and Maureen Maguire, Production Coordinator. Members of the unit who contributed to the editing and production were Peter Dews, Anne Wolf, and Kent Beaty.

TABLE OF CONTENTS

Introduction........ 1

Chapter I Sequence of Science Topics........ 3

Chapter II Planning and Implementation of the Elementary Science Curriculum........ 4

Chapter III Unit Plans and Lesson Plans........ 8

Chatper IV Approaches to Working with Children in Science........ 20

Chapter V Implementing the Discovery Approach in the Elementary School Classroom........ 24

Chapter VI Stimulating Science Interest........ 29

Chapter VII The Role of Questioning in Science Education........ 33

Chapter VIII Science Experiences: Forms and Varieties........ 41

Chapter IX Science Trips........ 46

Chapter X Activities in Environmental Science........ 49

Chapter XI Exploring the School and Its Vicinity........ 54

Chapter XII The Consumer in Chelsea (or any other neighborhood)........ 57

Chapter XIII Science and Reading........ 61

Chapter XIV Textbook Review........ 64

Chapter XV Elementary Science Needs-Assessment........ 70

Chapter XVI Elementary Supervisors Follow-Up Suggestions........ 74

Chapter XVII Resources for Improving Science Instruction........ 76

Chapter XVIII Science Fairs........ 80

Bibliography........ 84

Appendices........ 95

APPENDIX A What Research Says........ 97

Student Worksheets and Diagrams

APPENDIX B-1 Parallel and Series Circuits........ 99
APPENDIX B-2 Behavior of Mealworms........ 101
APPENDIX B-3 Can You Find?........ 104
APPENDIX B-4 Lifestyle Survey Form........ 107

INTRODUCTION

New York City has recognized the need to reinforce and enrich the teaching of science in our public schools by providing staff development for teachers and supervisors. This publication was produced to assist in this effort and to provide a resource for those involved in upgrading science instruction. The 1984 edition contains revisions that were prepared in response to the needs expressed by teachers who attended the 1982 and 1983 summer Science Staff Development Programs.

It is hoped that this publication will be used as a guide for developing science programs in our schools. Its purpose is twofold: to encourage the implementation of the New York City science curriculum which serves as the basis of science instruction in our city's schools; and to assist teachers and supervisors in fulfilling the philosophy of this course of study by involving the students in the curriculum's interesting and meaningful activities.

Included in this publication are articles addressing the philosophy and methodology of teaching elementary science, model lesson plans, an updated bibliography, evaluation techniques, recommended activities for students and teachers and other pertinent information. The publication is intended to serve as a guide, not as a substitute for either the many excellent textbooks on science education in the elementary schools or for the science curriculum bulletins of the New York City Board of Education. Its purpose is to inspire and encourage teachers and supervisors to reinforce and upgrade science instruction in their schools.

CHAPTER I

SEQUENCE OF SCIENCE TOPICS

The following table indicates the specific topics which are developed in Prekindergarten--Grade 6 in seven areas of science. These topics are developed in the curriculum bulletins produced by the Board of Education of the City of New York.

Area	Pre-kindergarten	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Magnetism and Electricity 		A Magnet Holds On		Magnets	Electricity in Everyday Life	Finding Direction with a Compass	Batteries and Bulbs	Magnets and Electromagnets
Earth in Space 		Spaces and Places Light and Dark		Sunlight and Shadows	The Earth and the Sun	Our Nearest Neighbor in Space: The Moon	The Sun's Family	The Stars and the Universe
	Science in Food Science in Body Movements. All Kinds of Pets	What's Alive? Discovering With Our Senses Seeds and Fruits Discovering with a Magnifying Glass	Animals and Plants in Our Neighborhood	Animals and Plants in the Classroom	The Needs of Plants and Animals	Getting New Plants	Little Environments	From the Senses to the Brain
Sound and Light in Communication 		Sounds Around Us	Making Sounds		How Sounds Are Made	Sounds Travel: Sounds Can Be Recorded	Mirrors and the Reflection of Light	Light, Lenses, and the Camera
Weather 	All Kinds of Weather		Weather from Day to Day		Observing and Measuring Weather Changes	Weather and Climate from Season to Season	Climate and Weather	The Ocean of Air
Motion and Force in Transportation 	Science in Wheels Science in Blockbuilding	Uphill and Downhill Seesaws and Balances	Moving on Land and Water	Moving in the Air	Friction, Gravity, and Motion	Moving Things More Easily	Making It Go	Moving in Air and Space
Earth and Its Resources 	Science in a Sandbox Science in a Pan of Water	Heat Changes Foods Getting Wet and Drying Water Mixes with Foods After It Falls Blowing Soap Bubbles		Water, Soil, Rocks, and Air	Rocks and How We Use Them	The Water We Use	How Man Changes Materials	Molecules and Atoms

CHAPTER II

PLANNING AND IMPLEMENTATION OF THE ELEMENTARY SCIENCE CURRICULUM

Good planning is an integral part of effective teaching. Among the types of plans that teachers use are long term plans such as curricula, courses of study and unit plans. Short term plans are basically concerned with weekly, daily and specific lesson plans. It is mainly through the lesson plans that the goals and objectives of the long term plans are accomplished. The curricula are the guides for developing programs within specific areas.

The New York City Elementary Science curriculum is based on the process-content approach to science. Science is regarded not merely as an accumulation of facts and knowledge. Science is a way of searching for the truth. It involves utilizing the processes of science (questioning, observing, etc.) to discover answers to questions. In this method of education, students become active participants in the learning experience. As they explore, manipulate materials, measure, etc., they find answers to their questions. They are encouraged to question, learn to think logically and to make judgments based on evidence. These abilities can be used in all areas of the curriculum and carry over to life situations as well. After all, it is generally agreed that one of the main goals of education is the development of the ability to understand and get along in the environment in which one lives.

Design of the Curriculum

The New York City Elementary Science curriculum has been carefully developed to meet the intellectual and physical needs of the students on each grade level. It is a general science course of study and deals with the following areas: Earth in Space, Climate and Weather, Electricity and Magnetism, Living Things, Light and Sound, Motion and Force in Transportation, How Man Changes Materials, Earth and Its Resources. Each area has been spirally designed so that a background of knowledge and skills is developed. The topics within each area are sequential and follow each other in a logical order. The spiral development of the concepts provides a basis for logical and increasingly intensive development of skills and understandings.

It is important for teachers to be sure of the curricular content and to understand its goals and objectives so they are able to achieve them.

A. Introduction

The Introduction of each curriculum bulletin can be very helpful in providing the teacher with background in methodology and information concerning the approach to teaching science in the elementary school. It includes the objectives, philosophy and basic methodology for teaching elementary science as well as a sample science schedule and a chart showing the sequence of science topics in the grades.

It is strongly recommended that teachers and supervisors refer to this section when developing school and class programs.

B. Topics

Each topic (e.g. How Man Changes Materials) has two or more sub-topics. Within each sub-topic are:

1. Background for the Teacher

   This provides basic science information the teacher may need. Refer to the bibliography for more in-depth information. Children's books, which are often written by excellent authorities (e.g. Asimov, Selsam), can also serve as fine, easily understood sources of information.

2. Approaches and Learnings for the Student

   In this section, ways of motivating the topic are suggested. The significant concepts which the students should learn are indicated.

3. Problems and Activities

   Within each sub-topic several problems are presented with activities for solving each problem. Diagrams, charts, graphs are included. Following each problem and the suggested activities are those understandings which the students may be expected to learn.

4. Evaluative Activities

   In addition to these questions, teachers may create their own questions for written tests as well as other forms of evaluation (observation, oral tests, etc.).

5. Basic Supply List

   This is found at the end of each unit and indicates materials needed for the implementation of the topic.

6. Other Resource Information

   Guides to the use of tools and to plants in the classroom, an audio-visual list and bibliographies for students and teachers are included.

The curriculum is comprehensive, clearly written and is easy to follow. The activities are interesting and meaningful. Most of the materials needed to implement the activities are easily obtainable.

Suggestions for Using the Curriculum

1. Make a long term plan. This can be flexible. Select and present the topics in the order that will suit the needs of your class. (See sample schedule in the bulletin.) This makes it possible for you to arrange for trips and materials that will be suitable to the topic.

2. Include various kinds of lessons in the development of the topics, e.g. demonstration, guided research, investigation, trip, evaluation. Try to include as many hands-on activities as possible.

3. Use a variety of materials, audio-visual materials (films, film strips, transparencies, television programs, pictures), books, science realia.

Planning and Implementing the Lesson

1. Select the type of lesson you will give (demonstration, introduction to a unit, etc.).

2. Decide what your objectives will be, the concepts you want to teach, the objectives for the students (knowledge, skills, attitudes). Keep in mind the needs of your class.

3. Materials of instruction: Try to use a variety of materials. What materials will be needed? How much will you need? Will each student have materials or will the students work in groups? Check the materials before using them.

4. Consider the time you will need for the lesson.

5. Plan to involve the students in as much personal activity as is possible.

6. Distribution of materials: Select a method that is economical of time and energy. The baggie method is helpful in a hands-on activity. Each student or group receives the materials in a plastic baggie. At the end of the lesson, the materials are replaced in the bag and are then collected, to be used in the future. This is a good opportunity to involve students in helping to prepare, distribute and collect the materials.

Suggestions

Plan to involve the students in hands-on activities and oral response as much as possible. Lecture as little as possible. Don't tell. Give the students the opportunity to tell you.

Questioning is the key to good teaching.. Use your questioning techniques to encourage student involvement and response.

Make sure the students know what they are trying to find out, what they are investigating.

Use your chalkboard. It is one of the finest visual aids you have.

Use charts, graphs, to gather evidence and as a reference point for summation.

Select a topic. Use those problems that best serve the needs and interests of your group and which will best help develop the basic concepts stated in the introduction to the topic.

Develop a lesson plan suited to your class.

Refer to the basic supply list and bibliography in your curriculum bulletin.

Refer to the New York City Board of Education publication Science Safety: Grades K-12 to ensure safety practices in your classroom.

Capitalize on the interests of your students.

Other Science Bulletins

These are excellent sources of information and will help to enrich and reinforce curricular goals.

Science Safety: Grades K-12
Guide to Science Trips and Environmental Resources in NYC
Adventures On the Beach - Teacher's Guide K-12
Operation New York: Using the Natural Environment

Refer to other science bulletins.

NOTE: See chapter entitled "Resources for Improving Science Instruction" for specific method of obtaining guides.

CHAPTER III

UNIT PLANS AND LESSON PLANS

The main purpose for developing units is to have long term plans. There are basically two types of units: a) research units b) teaching units.

The Research Unit

This is a collection of suggested activities and materials of instruction and content dealing with a major topic, theme or problem. It is comprehensive in nature so it can be used on a selective basis. It is designed to provide ideas and to suggest materials which will help the teacher in developing a unit.

The Teaching Unit

This type of unit is a plan developed by an individual teacher to be carried out in an individual classroom. Although it is planned in advance, flexibility should be an important factor so that the class is able to respond to challenges and problems that may arise as the unit progresses.

Basic Factors of a Teaching Unit

1. It is planned in advance.
2. It relates experiences around a central theme, problem, topic.
3. It can bring together content from various areas and provide for a variety of experiences.
4. It focuses on content which is significant to the solution of the stated problems.
5. It helps to integrate and to reinforce other curriculum areas.

There are a variety of ways in which a unit can be developed. Basically it is a series of lessons or experiences which will help the students find the answers to their questions and which will help them gain skills and learnings.

Outline of a Teaching Unit

Grade level
Theme or topic
Objectives
Possible duration
Pre-launching or background material
Concepts to be developed
Activities
Materials of Instruction
    Science materials
    Printed materials
    Audio-visuals
Community Resources
    Trips

Integration with other curriculum areas - reading, math, etc.
Possible culmination
Evaluation
Follow-up assignment
Leads to other units

NOTE: See sample lesson plans which follow.

Lesson Plans

The plan for a specific lesson is a guide for achieving certain aims through carefully selected teaching and learning experiences within a set period of time. A well-planned lesson is the key to effective and interesting instruction.

There are many types of lessons and various ways in which to write plans for them. Basically, however, a good science plan includes the following:

Topic
Grade
Specific understandings to be developed
Problem (to be solved)
Objectives (may include those for the teacher as well as students)
Materials
Time allotment
Motivation
Procedure (includes key questions to be asked)
Summary
Evaluation
Follow-up

Evaluation is an important part of the lesson plan. It may be in the form of teacher observation and/or written tests and quizzes. The results of evaluation indicate whether the objectives of the lesson have been accomplished and can help the teacher in further planning.

It is essential to consider the time allotted to the lesson and to each part of the lesson. The time spent on a lesson depends on the grade level and attention span of the students, as well as their ability levels. Careful attention to this element of planning can ensure a smooth flow of the activities and the continued interest of the students.

Good planning will include a variety of activities as well as classroom procedures.

Included in this section are several types of lessons which have proven to be effective in the elementary classroom.

(See Chapter VIII "Science Experiences: Forms and Varieties.")

Sample Lesson Plan #1

Topic: Magnets

Grade: 2

Understandings: There is a magnetic field around a magnet.

Type of Lesson: Guided discovery
Students will work in groups of two.

Problem: "Over what distance will the force of a magnet attract a paper clip?"

Objectives: The students will conduct investigations with magnets. The students will use problem solving skills (observing, investigating, keeping records, generalizing) in finding answers to the stated problem.

Materials: Magnets, paper clips, graph paper (for groups of 2).

Motivation: Place a clip at one end of a table. Place a magnet near it. Ask, "How close will the clip have to be to the magnet before it will be attracted?"

After getting several answers say, "How would you like to find out for yourselves?" (Make sure the students understand what the problem is.)

Procedure: The students will work in groups of two. Distribute the materials. Allow the students to investigate for themselves for a while. Ask, "How far away did you hold your magnet before the clip was attracted?" "What would be a good way to tell exactly how far away the magnet was?"

Distribute graph paper. Ask the students to note that the paper is divided into squares. Use the square as the unit of measurement.

Instruct the students as follows:
"Mark an X on a line of one of the squares. Place your clip on it. Start about ten squares away from the X, or at a distance where the clip will not be attracted. Move the magnet gently and slowly until the clip moves to the magnet. Count the number of squares from the magnet to the X." Ask the students for the results. Note them on the chalkboard. "Shall we do this again?" Repeat the procedure at least twice. Note and evaluate data. Have the students judge what these data mean. Ask, "What is it that attracts the clip?" "Where does this pull come from?"

Summary: Ask the students to explain:

1. Why the paper clip was not attracted when it was 10 squares away from the magnet.
2. Why the paper clip was attracted when it was a shorter distance away from the magnet.

Evaluation: Teacher observation of pupil's responses to the following instructions:

1. Put the magnet at a place on the paper where you think it will attract the clip.
2. Put the magnet where it will not attract the clip.

Follow-Up Lessons:

1. Is the magnetic force the same in all parts of the magnet?
2. Will some magnets pull harder than others?
3. What part of the magnet has the strongest pull?

Sample Lesson Plan #2

Topic: Electricity

Grade: 3

Understandings: To be aware of the role of electricity in our daily lives. To develop skill in classifying, record keeping and in making generalizations from data collected.

Type of Lesson: Introduction to a unit.

Problem: "What does electricity do for us?"

Objectives: Students will be able to:

1. understand the importance of electricity.
2. make generalizations from observed and recorded data.

Materials: Chalkboard

Motivation: Tell the students a story about a blackout. Ask the students to tell how such an incident might affect them.

Procedure: Ask, "What jobs can electricity do for us?" Ask, "What things do you know that work by electricity that give us light?" List the answers under the heading of light. Proceed in the same way with heat, motion, and sound.

Categorize the answers of the students in the following form:

Light Heat Motion Sound (Communication)

Summary: Ask, "What does the chart tell us?" "What are the jobs electricity does for us?"

Assignment: Have students make a scrapbook - What Electricity Does For Us. Collect pictures from newspapers or old magazines. Make four sections in the book - Light, Heat, Motion, Communication. Put the pictures you find in the proper section of your book.

Other possibilities - Use of Electricity in the Home, Use of Electricity in the School, Use of Electricity in the Street, etc.

Follow-Up Lessons: Have the students bring in their toys that work by electricity. Give the students the opportunity to demonstrate how the toys work.

Take a trip around the school or street to observe uses of electricity.

Sample Lesson Plan #3

Topic: Electricity

Grades: 3 & 5

Understandings: Current electricity travels in a circuit. A circuit is composed of a source of electricity, a path and a load.

Type of Lesson: This lesson will be used as one of the introductory lessons to the unit - "Batteries - Bulbs" in grade 5. It will review grade 3 understandings.

Problem: "How can we get a bulb to glow?"

Objectives: The students will be able to:
. work with electrical materials.
. get a light bulb to glow.
. make observations and generalizations.

Materials: One of each for each student - D cell, 12 inches of insulated wire with 1 inch of insulation removed from each end, flashlight bulb.

Motivation: Ask, "What is the job of this bulb?" "How can we get it to do its job?" "What do we need?"

Procedure: Give each student the above materials. Encourage the students to find a way to get the light bulb to glow. After each student has had this experience, ask the students to explain how they were able to make the light glow.

Ask, "What materials did we need?" "What was the job of each object - the bulb, the wire and the dry cell?" Write this on the board:

OBJECT	JOB
Bulb	give light
Wire	path for the electricity
Dry Cell	source of electricity

Point out that the electricity flows from the dry cell through the wire to the light bulb and back again to the dry cell. Have the students trace the flow of the electricity. Point out the shape of the path (circle or other closed figure). Help the students to understand that this is called a circuit.

Summary: Ask, "What are the parts of a circuit?" "What else might we use instead of a bulb?" (bell, buzzer). "What is the job of each part of the circuit?"

Assignment: "What kinds of things that work by electricity are used in your home? What is the source of electricity? Make a list of 8 such things and tell where the electricity comes from."

Follow-Up Lessons:

1. Open and closed circuits.
2. Role of the switch in a circuit.
3. Kinds of switches.

Sample Lesson Plan #4

Topic: Electricity - Conductors and Non-conductors

Grade: 3

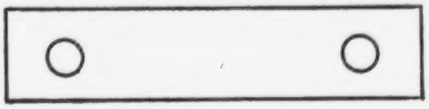
Understandings: Metals are good conductors of electricity. Non-metals are poor conductors of electricity and are called non-conductors. Non-conductors of electricity may be used as insulators.

Type of Lesson: Guided discovery
Individual investigation

Problem: "Which things carry electricity and which do not?"

Objectives:
1. To find out which materials conduct electricity.
2. To develop skill in making an electrical circuit.
3. To keep records of observations.
4. To make generalizations based on data collected.

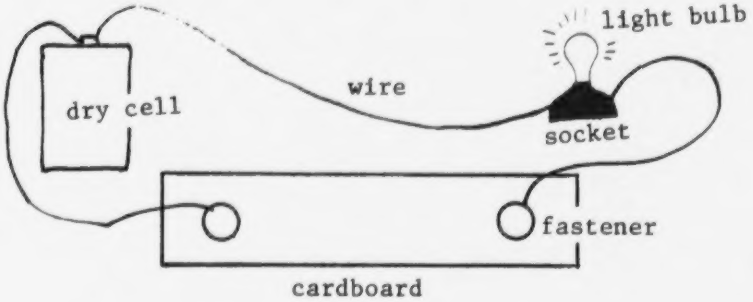
Materials: For each student - dry cell (D cell), 3 pieces of insulated wire (12 inches long, with 1 inch of insulation removed from each end), battery holder, bulb, socket, envelope containing an assortment of materials (paper, rubber band, button, coin, cloth, string, glass, nail, bare wire, etc.), piece of cardboard 4" x 2" with two brass fasteners inserted, one near each end.



cardboard with brass fasteners

Motivation: Review the parts of a circuit. Ask the students to look at the wires and tell why they are made of copper. Ask, "What other materials might carry the electricity?"

Procedure: Distribute the materials. Ask the students to make a closed circuit in which the bulb will glow. Ask them to modify their circuit in this way:



Have the students place the various materials as shown in the diagram, one at a time, so that the wires touch both fasteners. Ask the students to keep the following record:

What Materials Will Carry Electricity

Material	Light Bulb Glowed	Light Bulb Did Not Glow
Paper		
Rubber band		
Button		
Coin		
Cloth		
String		
Glass		
Nail		
Bare wire		
etc.		

Encourage the students to try other materials to find out whether or not they conduct electricity.

Summary: Review the results of the investigation.
Keep a record on the chalkboard.
Ask, "What do your records tell you?"
"What materials carried electricity?"
"What materials did not carry electricity?"
"What do we call materials that carry electricity?"
"What do we call materials that do not carry electricity?"
(either insulators or non-conductors)
"How do we use insulators?"

Assignment: "Look at 10 electrical applicances at home.
Where is insulation used?" "Why?"

Follow-Up Lesson: Make simple electrical quiz boards.

Sample Lesson Plan #5

Topic: How Green Plants Affect Man and Other Living Things.

Grade: 5

Understandings: All living things depend upon green plants for food.

Type of Lesson: Introductory lesson to unit

Time: 25 minutes

Problem: "Where does our energy come from?"

Objectives: Students will be able to:

1. understand the relationship between food and energy.
2. grasp the place of plants in the food chain.

Motivation: Ask a student to lift a pile of books. Ask, "Where did you get the energy to lift the books?" Help the student to understand the problem.

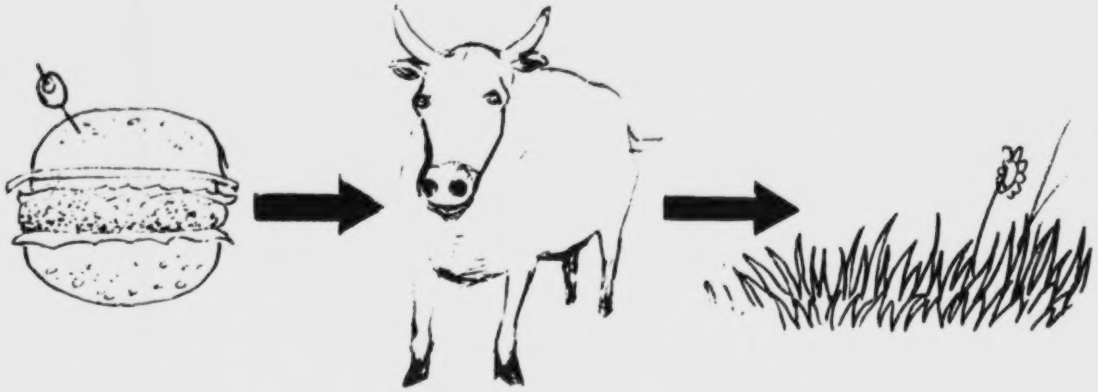
Procedure: Ask the students to mention some things they ate. List the foods on the board. Then ask the students to trace the food to its source. E.g.:

Milk → cow → grass (green plant)
Hamburger → steer → grass (green plant)
Egg → chicken → corn (green plant)

Review the list: Trace each food back to its source again. Enforce the idea that a green plant is the source of all food.

Ask: "What would happen if there were no green plants?"
"What do green plants use for food?"
Help the students to understand that green plants possess chlorophyll with which the plant can manufacture its own food if it can obtain air, water and sunlight. (This is called photosynthesis).

Summary: Ask the students to draw a food chain similar to the one below.



HAMBURGER ⟶ STEER ⟶ GRASS (GREEN PLANTS)

Assignment: "List four things you ate today." "Show where the food came from." "Draw a food chain for each food."

CHAPTER IV

APPROACHES TO WORKING WITH CHILDREN IN SCIENCE[1]

A good teacher uses a variety of approaches to teaching. If variety is the "spice of life," it is the "salt and pepper" of good teaching. In this presentation, several approaches to working with students in science are described, and a concrete example is given for each approach. Obviously, there are other approaches and many more examples.

The Laboratory Approach. A key feature of the laboratory approach is that each student is directly involved in using and handling materials. It is a "hands on" approach. In the elementary school, the classroom is usually the laboratory. Desks provide flat surfaces.

Many of the materials needed can be found in the school or local community. Sometimes it is desirable to have the materials organized into small kits that can be used in several classrooms and then saved for another year. Sometimes there will not be enough equipment to have all the students do the same science activity at the same time. Then, different activities can be set up on different tables or in different parts of the room. When the students have completed one activity, that group can move onto the next.

For some laboratory work, it is desirable to have each student work individually. In many cases, however, it is advisable to have two or three students working together. Care should be exercised to make certain that all students take part.

Ex. The paper electroscope. A simple electroscope made of newspaper can easily be assembled and used to detect electric charges and to determine their sign.

Hang a long strip of gray newspaper over a support such as a finger or broomhandle. Charge the paper leaves of the electroscope by pulling your fingers along the sides of the paper. When the leaves of the electroscope are charged, they should tend to deflect each other.

Rub a plastic knife with wool and bring it near the charged paper electroscope. What happens?

How can we determine the sign of the charge on the paper?

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[1] This presentation is adapted from "Working with students in science," in Willard J. Jacobson and Abby Barry Bergman, Science for Children. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1980.)

Cooperative Investigations. In a cooperative investigation a group of students or an entire class takes part in the investigation. The actual physical operations may be performed by individual students or the teacher. In the cooperative investigation, ideas and suggestions about teaching students how to conduct an investigation may arise.

Ex. *The case of the disappearing streak.* Wet your finger and then make a wet streak across the chalkboard. Have the students observe very carefully and then describe what happens. Then, ask the students to try to explain what happened. Discuss each suggestion. Then, ask the students to suggest investigations that would test the suggestions made.

Encouraging Imagination. One of our important aims in science education is to stimulate the imaginations of our students. In many cases, even "wild" ideas should be given serious consideration. There are science activities designed to stimulate imaginative suggestions.

Ex. *What could have happened to the streak?* Have the students suggest as many possible explanations for the disappearance of the water on the chalkboard as they can. Groups of students have suggested as many as 16 possible explanations for the disappearance of the wet streak including: "It was soaked up in the chalk." "It just disappeared."

Demonstrations. In a demonstration we show the operational meaning of some scientific generalization, a particular procedure that we want students to learn how to do, or how some scientific apparatus works. We may demonstrate the operational meaning of Newton's Third Law when we release an inflated balloon, or we may demonstrate how to use a microscope, or how to mount a human hair so that it can be viewed under the microscope. Demonstrations should be as simple as possible, and all parts of the demonstration should be visible to all students. Students should be encouraged to ask questions about the demonstrations. Demonstrations often evolve into cooperative investigations.

Ex. *What variables should be controlled?* A simple swinging pendulum can be used to determine what variables have to be controlled to study the factors that affect the number of times a pendulum will swing back-and-forth in a given period of time. What affects the number of swings? Weight of the bob? Length? Distance pulled back?

The experience of learning how to control variables is believed to be the kind of experience that helps students eventually achieve logical, formal operations.

Controlled Experiments. In the elementary school, students should have many experiences thinking through what variables have to be controlled in order to study the effect of altering one variable. They should have experience doing this as a laboratory experience and as a demonstration and cooperative investigation.

Ex. Which object will strike the floor first? The heavy object? The light object? Hold a heavy object and a light object above the floor and ask, "If I drop these objects, which one will strike the floor first?" Alter such variables as: the height of each above the floor, time of dropping, and whether one is pushed and the other dropped.

Investigations. Investigations are studies of questions or problems for which the answers are not known. In conducting investigations students have some of the same kinds of experiences that scientists have when they investigate questions and problems. There are lists of problems and questions that can be investigated; additional problems will arise as we work with students in science.

Ex. On what kinds of surfaces will bread molds grow? Bread molds will grow on bread left in a dark moist place. Transfer some of the bread mold onto such surfaces as paper, leather, plastic, open apple, potato, and wood.

Stimulating and Nurturing Curiosity. Through their experieences in science, we hope the students will become even more curious about the world in which they live. One of the most effective ways of stimulating and nurturing curiosity is for the teacher to be curious about the world in which she/he lives.

Ex. I'm curious. One week observe some phenomenon that you cannot satisfactorily explain. Use all the resources that are available to you in your home, school, library, museum, and among your friends to try to find an explanation for the phenomenon. For example, "How come we see many earthworms on the surface of the ground after a rain?" Report your investigation to your students.

Next week, ask your students to observe something that they are curious about and for which they do not have a satisfactory explanation. Ask them to try to find an explanation. What are they curious about? How do they go about trying to find explanations?

Projects. Projects are special undertakings of students or groups of students. They may involve construction of models or special apparatus, library research, or special surveys.

Ex. Projects like:
Construction of a model air tunnel.
Adopting and describing changes in a tree.
Collecting children's books on the planets.
Making a survey of the kinds of food discarded in the cafeteria.

Field Experiences. Field experiences may be broadly defined as experiences that students have outside the classroom. Field experiences may be taken within the school to study communications systems or ways of heating and cooling a building, on school grounds to see how many different kinds of insects can be found, in neighboring parks to study trees or geological phenomena, on visits to environmental centers; and camping at special sites during school.

Ex. *The parks within New York City* are an important resource. Morningside Park, for example, has been studied intensively, and it has within it as many geological features as any comparably sized area anywhere. Programmed field trips have also been developed for Central Park. Various private and public agencies have considerable information about the parks in New York City.

Using the Resources of the City for Experiences in Science. New York City has unmatched cultural resources for science education, and optimum use should be made of them in developing science experiences for our students. Our museums, planetaria, botanical gardens, zoological parks, libraries, and special sites have a great deal to offer. Most of these centers of culture have had a great deal of experience with students.

Ex. *The South Street Museum*, with its ships and its artifacts of a bygone age of sail, can be a place where a great deal of science can be combined with interesting history.

Colloquiums. Colloquiums are meetings where students have a chance to report on investigations that they have undertaken, projects, special studies, or unusual happenings. The communication of ideas and the results of studies is an important part of science. We can work with students to improve their communication skills as they prepare to present reports to their colleagues.

Ex. *A fourth grade held a colloquium* worthy of their elders as students reported their studies of phenomena related to magnets.

CHAPTER V

IMPLEMENTING THE DISCOVERY APPROACH IN THE ELEMENTARY SCHOOL CLASSROOM

Our science course of study is based on the discovery approach. What does this mean? The way a scientist searches for truth is called inquiry. The application of the scientist's method of inquiry to teaching is referred to as the discovery approach.

The basic objective of the discovery approach to science is to teach the student how to learn. This methodology helps students acquire knowledge which is personal and meaningful because the students discovered it for themselves by handling materials, by being involved in the experiences. Knowledge is obtained by one's own mind, by using various processes and skills. A result of this kind of learning is the development of concepts, some new to students, some simple and some more complex.

In a classroom where the discovery approach is used, students are motivated to question, to seek answers through problem solving and through first hand experiences. This implies, of course, that many divergent questions are being asked by the students and the teachers. (See Chapter VII, "The Role of Questioning in Science Education.") One of the most valuable tools a teacher can utilize in implementing an inquiry-centered program is questioning. The ability to question, to probe, to seek solutions are key characteristics of a well-educated person.

Communication is one of the major science skills. Therefore, when questioning is utilized, this skill is also reinforced. Remember also that when questioning is used, many language skills are enriched and improved. Students are being asked to listen not only to the teacher, but to each other as well. They exchange ideas and use many new words, thus increasing their vocabularies. Reading and writing are reinforced when students are asked to respond to written questions or to make up their own questions.

It is acknowledged by educators that the development of a questioning attitude in students is one of the major goals not only in science but in all curriculum areas.

When questioning is properly used, the classroom becomes a place where students are encouraged to inquire, to explore, to find out. School becomes a place where students feel that their questions are important; it is a place where they can find answers.

Questions properly asked and properly answered are the keys to effective, stimulating science teaching. Questions are the starting points for investigation and give purpose and direction to activities. Both the students and the teacher should be involved in the process of questioning. It is essential, therefore, for the teacher to understand more clearly what good questioning techniques are.

Students develop the ability to define a problem, identify possible causes, suggest probable causes and possible solutions as well as to predict likely consequences.

Activities like these foster the development of critical thinking, creative learning and the development of the student's own ideas. The involvement of the student in defining the problem, selecting the methods of investigation and suggesting possible solutions results in the acquisition of knowledge and skills that will not be easily forgotten.

The open-ended approach is an essential aspect of the discovery approach. The student tries to find solutions to a problem by exploring all possibilities. There is no one right answer to the problem. One solution leads to other possibilities.

There are basically two types of approaches to discovery learning, the guided approach and the "pure" approach.

Guided Discovery

1. The problem is planned and stated by the teacher.
2. Materials for the investigation are selected and distributed by the teacher.
3. Data sheets are developed by the teacher or other authority.
4. Investigations are made by the students individually or in groups.
5. Students collect and record data.
6. The teacher acts as a guide.
7. Students have common experiences and come to similar conclusions.
8. Each lesson is formal and planned.

Pure Discovery

1. The teacher supplies each student or group of students with materials.
2. The students work at their own rate with the materials.
3. The students define their own individual problems and methods of finding solutions.
4. Each student or group performs the investigation that they have designed.
5. The teacher acts as a guide. The amount of direction can vary according to the teacher, class and/or ability of the students.
6. Divergent questioning by the teacher is implied.

In a pure discovery situation, the teacher might put the materials, (e.g. items used in a unit on electricity for the fifth grade), on a table. The students would select materials and work with them, deciding what the problem for discovery might be, how to do the investigation, etc. As a result, one student might find various ways to light a bulb, others how to make a circuit with a bell as the load, another might work on series or parallel circuits, etc.

Both methods require careful planning. It is essential that the processes and skills of science are taught. They are not learned haphazardly or automatically.

Problem solving is one of the most essential skills but also one of the most difficult to learn. It is not always easy to be able to identify the problem or question in a situation. The problem of the inquiry must be a problem seen by the student, one that is established as a result of the situation presented. Through planned activities and experiences, students can develop ability in this area.

Motivating a Discovery Lesson

Many questions may arise from unplanned situations in the classroom or from personal experiences of the students. In order to develop questioning related to the science concepts planned for the particular grade, the teacher can guide and stimulate questioning and the defining of a problem in a particular situation. A number of strategies may be used. These are some suggestions.

1. Demonstration

   Plan a demonstration that works (or better still, one that doesn't work). For example show a parallel circuit with three bulbs, one of which is not glowing. Then have the students ask questions and suggest ways to investigate and to predict the kinds of solutions they may find.

2. An anecdote concerning a particular situation

   A farmer had a pond to which ducks came each year. One year he decided to grow crops in a field near the pond. He fertilized the fields with a new chemical. His crops grew well, The following year the ducks came back as usual. However they never came back in subsequent years. Why?

3. A newspaper article which presents an issue

   Tuna fishing and the declining population of porpoises.
   Air pollution caused by heavy traffic.

4. Data

   Chart or figures which represent a situation:
      Decline in population of salmon.
      Data concerning the use of fossil fuels.

5. Pictorial - pictures, drawings, filmstrips

   A devastated hillside, a littered street, birds on the beach with their wings covered with oil.

6. Realia

   An object, living or non-living, which illustrates a particular concept.

The Investigation

Once the problem has been defined, suggestions can be made for finding the solutions. The students should understand what a variable means and that the validity of an investigation depends upon a control, the testing of one variable at a time, and the need to repeat an experiment many times.

In an open-ended investigation, the answer should not be evident at the beginning of the experiment. The students should have the opportunity to make predictions and to suggest various ways to find the answers. Questions such as these might be used.

What might happen if ...?

In how many different ways ...?

What other ways are there ...?

Open-ended Ideas

1. Mirrors
   In the study of mirrors, the students learn that a silver backing on glass makes a good reflecting surface. What other kinds of backing might be used on glass? The students might suggest: a) type of material (paint, metal, foil, etc.), b) color - in this case the variable would be color and the material would be a constant, e.g. various colors of paint, c) paint - various kinds of paint (flat, enamel, oil paint, water-based paint) might be considered.

2. Electromagnets

   How can the strength of an electromagnet be changed? Does the kind of core affect the strength of the electromagnet? Variables to be considered include: a) material of which the core is made, b) its width, c) its length.

   How does the number of turns of the coil affect the strength of the electromagnet?

   What is the greatest number of paper clips that can be picked up by an electromagnet using one dry cell?

3. Surface Tension

   What is the largest number of paper clips you can put into a one-ounce measuring cup filled with water before the water spills out of the cup?

   Each student investigates and records his answer. If the answers vary, the students suggest reasons for the variation.

   Repeat the investigation with other liquids instead of water. Variables might be oil, alcohol, salt water.

Questions Which Can Lead to Open-ended Investigations

1. How can you find out if fish see?
2. In how many ways can you collect the heat of the sun?
3. What is the best way to keep an ice cube from melting?
4. How much difference does the slant of the sun's rays make in the amount of heat received by a surface?
5. What is the best way to make a mirror?
6. In how many ways can you make a kaleidoscope?
7. In what kind of light will bean plants grow best?
8. What kinds of fish can live in the East River, a Central Park pond, in the Atlantic Ocean?
9. In what kind of environment will clover grow best?
10. What are some ways we can get fresh water from salt water?
11. How can we make vinegar? The variables might include materials, amounts of materials, temperature.
12. Why do the trees on our streets have different shapes? The variables might include kind of tree, location, traffic, damage to tree, availability of light.

In each case, there are many open-ended questions. The number of variables depends upon the students' questioning. These are determined by the students' experiences, creativity and knowledge.

As the students question, investigate and try again, they develop skills and concepts which help them to build a background of knowledge. They learn that an experiment must be done over again, often many times, to verify results. Open-ended questioning and investigations lead to critical thinking and evaluation of ideas and situations. The product of this kind of education is a person who is knowledgeable, open minded, logical, aware and appreciative of the beauties and wonders of our world.

CHAPTER VI

STIMULATING SCIENCE INTEREST

Interest in science can easily be stimulated in children. Children are naturally curious about the world around them. Once aroused, this interest and desire for knowledge can be channeled to develop concepts and skills not only in science, but in other curriculum areas. A student's interest in a specific topic can lead to reading research, investigation, construction and artistic expression. Very often a heightened interest can lead to the development of hobbies and serve as a career incentive. When students are involved in science activities that are of special concern to them, their ability to express themselves orally and in writing often improves. There is a reason to read; there is something relevant to talk and write about.

These are some ways science can be stimulated in a school setting.

I. In the Classroom

A. Provocative Displays

1. What is It? - Have a special place where you or the students can place an item of particular interest. You can set aside a certain time when you and the students can discuss the item, or you may ask the students to write its name on slips of paper and place them in a suitable receptacle. At a specific time, their answers can be reviewed and discussed.

2. Specimen of the Day, of the Week - How Does It Work? - Place an object on display where the students can individually examine and study it. The answers concerning the way the object works can be written down or described orally. Encourage the students to formulate their own questions about objects.

3. Which Is Bigger? - Display items. Have scales, measuring tools and paper available. Have the students measure the various items, record their measurements and compare them.

4. Sharing Spot - This should be a place where the students can bring in items to show to their classmates. Set up a routine in which the students can talk about their contributions and share their experiences.

5. How Do Animals Grow? - Have pictures or specimens of plants and animals in various life stages, which the students can study and examine. Puzzles which show life stages are available. Set up an insect nursery (mealworms, sow bugs, caterpillars). Students can make insect cages from milk cartons or shoe boxes. Have the students keep records of the changes. These can be done with drawings as well as with written and numerical notations. Labels, poems and stories can reinforce language skills.

6. Leaf Mobile - Display various kinds of leaves by suspending them in some form of mobile. You can do this with other things such as simple tools, seeds, animal pictures, food chains, etc. These mobiles can be made by the students.

7. "Feelies" - Prepare a container in which there are objects of various textures and materials. Ask the students to feel them and then to describe and name them. Set up a "Sense Center" where the students can feel the textures of various materials, e.g. feathers, ribbon, shells, sandpaper, soap, marbles, etc. Have the students verbalize their perceptions. Set up a matching situation where objects of similar tactile sensations can be grouped together.

8. "Smellies" - This display can easily be prepared from simple materials. Use old pill containers or baby food jars. Place some absorbent cotton in the bottom of each container. Put materials such as perfume, nail polish remover, vanilla, etc. on the cotton. Cover the container and put a number on it. Make a card noting what material is in each of the containers. Give the students the opportunity to spend time investigating these materials. Ask the students to describe the odors. Discuss odors which are related to various situations or environments. Ask the students to suggest other materials to be used in the "Smellie" display.

9. Bulletin Boards - Topics can be introduced by colorful, stimulating displays. As the topic is developed, the work of the students should replace the initial display. In some cases the initial display can be made by the students.

B. Books - The display of books on a particular topic can stimulate interest in that area and encourage reading. Ask the students to bring in books they find especially interesting.

C. Films and Filmstrips - There are many excellent visual aids of these types which are not only interesting and exciting but are valuable teaching tools. Students can develop original filmstrips.

D. Pictures - Keep picture files. Large pictures can be used for displays, parts of a lesson, sequence stories and to encourage observation and discussion. Use pictures you have captioned to encourage predicting, hypothesizing, observation.

E. Stories - Storytelling by students, teachers or visitors, flannel board stories, unfinished stories, (initiated by teacher or students and then finished by the students), are some ways the language arts can be used to reinforce science concepts. Original poems and stories concerning special interests in science can reinforce science experiences.

F. Newspaper Articles - These can be used to verify information, initiate discussion, and to collect information and statistics. One way to stimulate discussion is to present information and to ask, "Do you believe this?"

G. Record Keeping - Have charts for collecting various kinds of information, e.g. weather, growth of plants and animals, moon phases, collection of cans for recycling, kinds of birds seen, kinds of cars passing the school, etc. Use the records for interpretation of results, generalizing and reaching conclusions. In some cases the students may come up with new ideas for conducting a portion of the investigation.

H. "Find Out Station" - A very valuable part of any classroom, is the area where students can go to investigate and to experiment. Manipulative materials help students develop skills, satisfy curiosity and to make discoveries on their own. Task cards with the necessary materials are excellent for this kind of activity.

I. Weather Station - Keep class and individual records. "Weather reporters" can be assigned daily or weekly responsibilities. Keep records of unusual weather occurrences.

J. Animal Corner - Students should learn about the habits and needs of each animal. Records can be kept of the growth of animals, food consumed, etc. Menus can be made up for animals in the classroom. An "Animal Cafeteria" can display the kinds and amounts of food each animal needs. Make sure the students understand the need for and ways of practicing humane treatment of animals.

K. "Investigating the Environment" - Do you know? - How does water get into the school? How many kinds of materials made from rock are there in our school? What kinds of trees grow in our neighborhood? Are all streets built the same way?

L. Science Hobbies - Encourage students to discuss and demonstrate their special interests in science. This may encourage other students to become involved in individual activities.

II. School-Wide Activities

These activities require planning and organization. When properly implemented, they can spark interest throughout the school, not only in the students and teachers, but in the parents and community.

A. Science Fairs - These can be implemented in several ways, but should suit the needs of the school. Ideally a science fair should show what the students have done in their classrooms.

1. Whole School - The selection of the theme for a fair depends upon the focus of the school. It can be done in a variety of ways. A topic can be selected by each student, each class, each grade, or the entire school. A school may decide to work on a specific topic, e.g. The Consumer in Our Neighborhood, Energy, Communication, Electricity. In such a situation each class selects an area suitable to its interest and ability and develops it. This will result in an overview of the topic at the fair from kindergarten to the highest grade in the school. This is an excellent way to implement our course of study and to see its spiral development.

2. Grade or Class - A grade or class may want to show its work and invite the rest of the school to see it.

B. Science Hobby Show - Students are invited to display and discuss their special interests. This event can be set up in the same way a school will set up a science fair.

C. Science Institute - This program is based on the individual science interests of the students and on the cooperation of scientists in the area. It is most suitable for grades 4-6. A survey is made of the students' interests, e.g. space, computers, insects, fossils, etc. A list of 14 to 16 topics is obtained. Invitations are then sent to scientists who are specialists in those fields. A date for the institute is set (usually about two months ahead). In the meantime the students work individually on their topics. The teachers and librarian are asked to assist.

On the day of the institute, the scientists who have accepted the invitation are greeted and escorted to rooms where they meet students who suggested a particular topic. The methods of presentation may vary from slide presentation, to chalk talk, to hands-on workshop; often it is a combination of the above. The presentation is scheduled to take about one hour.

The scientist then leaves the room. A summary is made of the presentation by the students and the teacher assigned to that room. Two or three basic questions which will be presented to the scientist are formulated.

About thirty minutes later all the involved classes meet in the auditorium. Each scientist is seated on the stage with two of the students he or she worked with. One student will then present a summary of the presentation; the other will then ask the scientist to answer the questions developed by the class.

In this way all the students involved in the institute will be presented with an overview of what went on in the various sessions.

The Parents' Association is usually involved in helping implement this program. It has proved in most cases to be an exciting, fruitful program and has helped to bring school and community closer together.

D. Flower Show - This is an excellent way to implement the unit on Living Things, K-6. In addition it is usually a beautiful presentation.

E. Pet Parade - The interests of many students can be involved. Focus should be placed on the humane treatment of animals.

F. Arbor Day - Other Special Events - There is no limit to the kinds of activities in which the students can be involved. It depends on the interest and creativity of the faculty. The results are well worth the effort.

CHAPTER VII

THE ROLE OF QUESTIONING IN SCIENCE EDUCATION

One of the most valuable tools a teacher can utilize in implementing an inquiry-centered program is questioning. The ability to question, to probe, to seek for solutions are key characteristics of a well-educated person.

Communication is one of the major science skills. Therefore, when questioning is utilized, this skill is also reinforced. Remember also that when questioning is used, many language skills are enriched and improved. Students are being asked to listen not only to the teacher, but to each other as well. They exchange ideas and use many new words, thus increasing their vocabularies. Reading and writing are reinforced when students are asked to respond to written questions or to make up their own questions.

It is acknowledged by educators that the development of a questioning attitude in students is one of the major goals not only in science but in all curriculum areas.

When questioning is properly used, the classroom becomes a place where students are encouraged to inquire, to explore, to find out. School becomes a place where students feel that their questions are important; a place where they can find answers.

Questions properly asked and properly answered are the keys to effective, stimulating science teaching. Questions are the starting point for investigation and give purpose and direction to activities. Both the students and the teacher should be involved in the process of questioning. It is essential, therefore, for the teacher to understand more clearly what good questioning techniques are.

Reasons for Questioning

First let us explore why teachers ask questions. What are some of the reasons for asking questions? These are some purposes for which questioning can be used:

- to find out what the students know
- to motivate students to think critically
- to stimulate creative thinking
- to lead students to higher levels
- to review what has been learned
- to arouse interest in a topic
- to encourage the students to develop a questioning attitude
- to summarize
- to evaluate the achievement of the objectives of the lesson.

Basic Types of Questions

The effectiveness of questioning techniques depends on the type and number of questions asked. Surveys have shown that teachers ask too many questions and students ask too few. It has been estimated that on the average a teacher asks twenty seven questions for each question asked by a student. Many of the questions teachers ask do not develop higher thinking skills. The reason for this is that these questions require only memorization of the answer. This kind of question is known as a convergent or closed question. It focuses on a specific fact or on direct information. There can be only one right answer to this kind of question; e.g.: "How many legs does an insect have?" "How does the length of an iron rod change when it is heated?"

This type of question has its place in the classroom, and can be used in an inquiry program to check data and measurements or to find out why an investigation does not work. Exclusive use of such questions however, results in focusing on the lowest level of learning - memorization. Convergent questions call for thought processes based on simple recall, definition or observation. These questions may often imply that what is really important is not what the students think or what the information tells them but to believe what they have been told. In a situation where this type of questioning is used almost exclusively, the students, for fear of answering incorrectly, may not answer at all. They may begin to feel that it is better not to make a mistake than to think. They try to guess what answer the teacher wants.

On the other hand, divergent or open questions can stimulate the student to think in many directions and to consider a number of possibilities as answers. There is no one right answer to a divergent question. Such questions encourage a variety of responses. They motivate students to think and to investigate; e.g.: "How can you prevent a nail from rusting?" "In how many ways can you make an electromagnet stronger?" Divergent questions expand any area of study. Open questions usually require an explanation rather than a statement of fact or a few words as an answer. Open questions can encourage all students to participate in the lessons and in addition can encourage students to develop their own interests.

Science may be divided into two major areas: content and process.

The content of science is the organized body of knowledge that has been acquired by employing the scientific processes. Most of the content of science consists of scientific facts, concepts, generalizations, principles, laws, and theories.

The processes of science include observing, measuring, realization and formulation of problems, hypothesizing, designing experiments, performing experiments, record keeping, analyzing, interpreting, classifying, grouping, inferring, synthesizing, drawing conclusions, extrapolating, formulating models, evaluating and communicating.

Convergent questions are concerned almost entirely with the content of science, whereas divergent questions may be used effectively to involve students in the processes of science. In doing so, divergent questions help the students develop some of the worthwhile attitudes and characteristics scientists are expected to possess. These include curiosity, open-mindedness, skepticism (questioning attitude), persistence, willingness to accept constructive criticism and a willingness to share.

Consideration of these functions of the two basic types of questions makes evident the value of the use of divergent questions, along with some convergent questions where appropriate.

Encouraging Students to Ask Questions

The teacher's manner is of prime importance in developing an atmosphere where students feel free to ask questions and to find answers. Each student should feel that his or her question is important.

It is more important for a student to feel free to ask a question than to feel that he or she must give the correct answer each time. Where the teacher is willing to acknowledge that a good question is as worthwhile as a good answer we have a classroom in which students are being taught to think, and use their reasoning skills.

Students should understand that answers can be found in many ways. They should be encouraged to find them through investigations, books, or by asking authorities - including the teacher. But the answers they discover themselves through their own efforts are the ones that are most meaningful to them and the ones that they are most likely to remember.

One aspect of questioning is understanding that there are many questions in science which remain as yet unanswered. These questions will lead to research and perhaps someday some answers will be found.

Students should be helped to understand that there is no final and absolute authority in science. New discoveries are made constantly and answers to questions change with the acquisition of new data and more refined science tools. Just consider the discoveries being made concerning the formation of new portions of crustal material at the mid-ocean ridges or the number of rings around Saturn.

Techniques of Questioning

The effective use of questioning is dependent on good planning. Teachers should know specifically what they want to teach. Based on this information, they can then plan what they will question, the types of questions they will use and the kinds of answers they will accept. Planned questions are essential to a good lesson. This does not eliminate, however, the questions that may arise in class from the activities and interests of the students. These should also be given time and attention.

These are some questioning techniques which may prove helpful to you.

1) Plan questions which deal with science processes as well as science content. In what ways are the leaves we have collected different? (observation, classifying) What do you think will happen if you use a thicker string? (predicting)
2) When you use convergent questions make sure the students have had the background on which to base their answers.
3) Use questions that make students think (divergent type). Why is a drop of water shaped like a globe?
4) After asking a question, wait and then call on a student. Give the students time to think before calling on them to answer.
5) Acknowledge the effort to answer a question even if the answer is not totally correct. If the teacher's response to incorrect answers is punitive or a source of embarrassment, students may hesitate to try to answer. Encourage the students to think, to try to find the correct answer.
6) Make the students feel you are sincerely interested in their answers. Keep eye contact with the student who is replying.
7) Your response to the answers should encourage higher level thought. "What could be another example? What can be added to Joan's explanation? What might happen if (...) condition were changed?"
8) Be positive in your responses to the students. Instead of the usual "Correct," "Wrong," Right," "Okay," use "Well done!" "Good try!" "You're doing a fine job!" "Interesting idea!" "That's really good!"
9) Encourage the students to ask questions and to bring in questions. Have a question box, "Question of the Day," "Can You Answer This?" etc. You might also use a bulletin board for this purpose. Set aside a time of the day to discuss the questions and answers with the students.
10) When a student asks a question, you might ask "What do you think?" If the student who asked the question cannot suggest an answer, ask the class for possible answers. Be slow in giving the answers yourself.
11) Try to get all the students involved. Ask easy questions occasionally so that every student gets a chance to feel a part of the lesson.
12) Use a variety of questions in addition to how, what and why questions; e.g. In how many ways, explain, prove, compare, trace, show how, etc
    Explain why the days of the planet Mercury are shorter than those on Jupiter.
    Show how you can make a strong magnet from a piece of copper wire.
    In what ways can you reverse the poles of an electromagnet?
    Compare the melting temperature of fuse metal to that of copper.
13) Make your questions simple, clear and direct. Do not use unnecessary beginnings such as, "Who can tell me why the sky is blue?" or "What do you think the reason is...". Instead ask, "Why is the sky blue?"

14) Ask your question, then wait a short timme before designating a particular student to answer. The attention of the whole class will be centered on the question and they will all feel involved. If you call on the student, then ask the question, the rest of the class may not feel the obligation to think about the answer.

15) Arrange interesting situations to stimulate the students to ask questions; e.g. displays, demonstrations, newspaper clippings.

16) Use acrostics and crossword puzzles. Those the students make up themselves are most effective.

17) Use pictures. Attach questions which ask the student to: a) find answers utilizing pictorial clues, b) make a hypothesis or prediction relating to the picture.

18) Prepare key questions you want to use, and your reasons for asking them. Properly planned questions can lead to desired activities.

Functions of Questions

Consider why you are asking questions. What activities will your questions lead to? These are some possible functions of questions.

1) Questions which draw on students' experiences:

   a) What kinds of tools can be found in your kitchen?

   b) For what purposes does your family use bleach?

   c) Why is baking powder used for cake-making?

2) Questions which lead to trips and surveys:

   a) How many different kinds of trees grow around our school?

   b) What natural rock materials can be found in your neighborhood?

   c) Which planets are visible in the sky this month?

   d) What kinds of gulls can be seen around New York City?

   e) Where in New York City are there buildings that use solar energy to heat water?

   f) Where are the fuses in your home?

   g) What kinds of fuses are used in the school building?

3) Questions which lead to close observation:

   a) What damage has been done to the trees near our school?

   b) What happens to the image in a mirror when you move the mirror toward the object?

   c) In what ways do spiders differ from ants?

4) Questions which encourage experimentation:

   a) How can you get starch from a potato?

   b) How can you make invisible ink?

   c) In what size jar will a three-inch candle burn the longest?

   d) In what kind of soil can water be absorbed fastest?

5) Questions which challenge students to propose explanations:

   a) Why do earthworms come out of the soil after a rain?

   b) How did weeds get into the school lawn?

   c) How do planets get their light?

   d) Explain why a straight stick looks bent when part of it is in a glass of water.

6) Questions which help students group and classify:

   a) What kinds of plants can be found in a lawn?

   b) What are the characteristics of metamorphic rocks (as compared to sedimentary rocks)?

   c) In what ways can lenses differ?

   d) How is a duck different from a robin?

7) Questions which lead to measurement and collection of data:

   a) How does the temperature of the pavement in the sun on a sunny day compare with that of the pavement in shade?

   b) Do plants grow better in sand or soil?

   c) How does the number of turns in the coil of an electromagnet affect its strength?

8) Questions which challenge students to propose ways to find out:

   a) How can you prevent a nail from rusting?

   b) What is the best way to slow down the evaporation of water?

   c) How can we find out which materials will conduct electricity?

9) Questions which ask students to predict:

   a) What will happen to the sound if you shorten the soda straw horn?

   b) What would the earth be like if there were no sunlight?

   c) If a jar of pond water is put in a shady spot what will happen to the algae in the water?

Practices to Avoid

1) A preponderance of convergent questions.
2) Yes-no questions; e.g. "Are all the leaves the same size and shape?" Instead you might ask - "In what ways do the leaves differ in size and shape?"
3) Anthropomorphic questions (those which give human characteristics to natural phenomena); e.g., "Why do magnets like iron?" Instead: "Why do magnets attract iron?"
4) Long-winded questions. Make your questions direct, specific, short, and use as simple language as possible. Don't make a science lesson dependent on high level vocabulary, except of course for scientific terminology.
5) Questions which require factual information your students cannot be expected to know.
6) Repeated attempts to elicit an answer after it has become obvious, despite rewording of the question, that students do not know the answer.
7) Questions that are vague; e.g. "Tell us about energy." Instead ask: "What are some forms of energy?" or "In what ways can energy be generated?"
8) Repeating students' responses. Call on other members of the class to repeat the answers.
9) Asking a whole series of questions at once. "What is photosynthesis, where does it occur, what are the materials necessary for it and what does it do for the plant?" Instead, ask each part of the question separately.
10) Statements that turn into questions; e.g., "The length of the mealworm that was fed on cornflakes is what?" Instead ask, "How long is the mealworm that was fed on cornflakes?"
11) Asking questions as punishment or as a means of embarrassing a student.

You'll know you've developed an atmosphere where students are thinking when they ask questions such as:

What would happen if ...?

How can we find out ...?

How can we do ...?

Where could we find ...?

In how many ways ...?

What happened ...?

Study your questioning techniques. Improve them where you can. The effort will be well worth while.

Consider the following bit of philosophy. "Wonder is the stuff that questions are made of. Questions are the stuff that makes dreams come true."

Encourage questioning both in yourself and your students.

CHAPTER VIII

SCIENCE EXPERIENCES:
FORMS AND VARIETIES

I. Introduction

Many teachers associate science lessons with doing experiments. Although the experiment has an important place in science teaching, it must be realized that science experiences and learnings come in many forms as well as varying in the periods of time they may take. The experiences can be short incidental experiences (such as the observation and discussion of what a student brought in), a formal developmental lesson, an investigation, a field trip, sharing ideas, demonstrating the results of a science experience, or performing an experiment. The presentation can be to the whole class, small groups or individual students.

II. Various Types of Science Lessons

A. The introductory lesson to a unit

This may be motivated by using a film, specimen, exhibit, anecdote, news article, demonstration or visual aid. It may involve discussion, divergent questioning, suggestion of problems to be solved and the application of observation skills.

B. Development of a specific science skill

This may include observation of shapes, color or texture or classifying, e.g. a lesson where students will discover which materials conduct electricity.

C. Development of a specific concept through the use of science skills

Examples: Some parts of a magnet are stronger than others.
Current electricity travels in a circuit.
Some things float; some things sink.

D. Performing an experiment

This type of activity reinforces the skill of problem solving. The students should be aware of the problem and ideally they should determine the problem in the situation presented to them. They should be involved in predicting, setting up the conditions for the experiment and selecting the necessary materials. The need for a control should be clear to the students and the variables should be determined by the students.

E. Making models or preparing materials with which to investigate a specific area

The students should know why they are making the model or preparing the materials and what they will do with them, e.g., humidity indicator, thermometer, pin wheel, balance (See section on "How to Make a Humidity Indicator" in the "Sample Experiment" which follows this section.)

F. Trips

1. Science observations are dependent on first hand experiences. Trips are an excellent way to gather information.

2. Sites

a. In the school:
What kinds of rocks were used in the construction of your school?
How does water get into the school?
In how many different ways is electricity used in your school?

b. Around the school:
What kinds of trees grow near our school? Make a tree guide.
What animals can be found near the school?
What is the structure of the street? How many different kinds of materials were used to build it?

c. Community resources, e.g., parks, museums, natural science centers, etc.

3. Preparation for a trip

In preparing students for explorations, they should be preparec to learn:
A. How and what to look for.
B. Ways to remember what they have seen.
C. How to conduct themselves.

4. Follow-up of the trip

The follow-up of trips can consist of discussions, written descriptions, collections, charts, records, diaries, stories, photographs, etc.

III. Criteria Used in Evaluation of Experiences

In evaluating the science experiences, these are characteristics to look for.

A. Every student is interested and involved.

B. There are as many first hand experiences as possible.

C. Manipulative materials are used. Where possible, materials are available for every student.

D. The objectives of the lessons are clear to the students.

E. The teacher acts as a guide rather than as a fount of information.

F. There is an application to daily living of the concepts developed.

G. The experiences are on the level of the students' understanding.

H. There is evidence that science skills are being strengthened, e.g., observation, record keeping.

I. There is evidence of the development of the students' appreciation of the interrelationships of science to the other curriculum areas.

Sample Experiment

How to Make a Humidity Indicator

Cobalt chloride is a deep purplish-red crystalline chemical that can absorb the moisture present in the air. An absorbent material which has been soaked in a cobalt chloride solution and then dried will change from pink to blue to pink as the amount of moisture in the air changes. Such a material is a fairly accurate humidity indicator and can be used in the classroom for many valuable and interesting science activities.

Materials Needed:

Cobalt chloride, salt (sodium chloride), warm water, absorbent materials (filter paper, white toweling, cloth, blotters, heavy cord, plain ribbon (not satin), a large piece of plastic material or any nonabsorbent surface. Art materials - scissors, stapler, colored paper, crayons, cardboard or oaktag.

Procedure:

Make a cobalt chloride solution, using the following proportions or multiples of them: 1 cup warm water, 2 tablespoons cobalt chloride, 1 teaspoon common salt.

a. Make the solution.
b. Soak the material in the solution until it has completely absorbed as much as possible.
c. Place the wet material on a piece of plastic or nonabsorbent surface until the material is completely dry.
d. Make a picture. Use a piece of the above material in a part of the picture. Do not paste the material. Staple it into place.
e. Write this legend on the bottom of the picture
    blue = fair weather
    pink = rain or cloudy weather
f. Staple the picture onto a heavier piece of paper or cardboard.
g. Other ideas -
    1. Make paper or cloth weather-flowers.
    2. Make an animal with a tail of the humidity indicator material (heavy cord).
    3. Make a mobile using shapes made of the indicator material.
h. Keep a record of the temperature, clouds, air pressure and the changes in color of your indicator. Are there any relationshps between the changes in other weather factors and those in your indicator?

Suggestions for Open-ended Investigations

a. Is the air more humid inside or outside a building? Design an investigation to solve this problem.

b. How accurate is your cobalt chloride indicator? Keep records of the changes in the color of the indicator and changes in the weather. What percentage of the time is your indicator correct?

DATE	COLOR OF INDICATOR	KIND OF WEATHER

CHAPTER IX

SCIENCE TRIPS

A great deal of learning takes place outside the classroom. In exploring the neighborhood, and on visits to parks, zoos, botanical gardens, museums and other institutions, new worlds are opened up for the children. The city street, the empty lot as well as the fields, forests, ponds, rivers and ocean beaches offer many rich opportunities for the study of science. Science learned by investigating the relatively natural environment and the urban environment and by visiting institutions can reinforce and enrich the whole curriculum as well as offer experiences which may benefit the student throughout his or her life.

Trips should not be considered as simply supplementary to the curriculum. They can be a vital part of the student's educational experience. This applies both to the content of knowledge and the methods of discovery implicit in our elementary science curriculum.

Learning does not happen simply because a trip is taken. The trip should be planned and conducted in such a way that it is a true learning experience. Every trip should have a special purpose and each child should know that purpose. Children learn best when they are directly involved and are active participants in the educational experience.

A trip can be the basis for integrating many areas of the curriculum - reading, mathematics, art, social studies. It can also be an excellent motivation for creative expression and research.

The following guidelines are suggested for setting the stage before a trip, for conducting the trip and for activities following the trip.

Techniques In Trip Taking

Why a Trip?

Trips:

- Provide firsthand experiences with materials and phenomena.
- Provide a variety of vivid and enjoyable experiences for children.
- Bring the children into the world outside the classroom.
- Provide opportunities for witnessing phenomena which cannot be seen in the classroom.
- Enable children to see materials and phenomena in their true or natural relationships.
- Help children see more clearly how science applies to the environment.
- Invite children to use the environment as a laboratory - for observation, for investigation of problems.
- Help develop ecological concepts - interrelationships of man, plants, animals and the physical environment.
- Help children see continuity and change in nature.
- Help children develop attitudes of conservation.

Before The Trip

- Set the stage with the unit problem or concept to be studied.
- Motivate by introducing possibilities of interesting explorations among the selected offerings at the resource agency and thereby develop a better understanding of the scientific concepts under discussion.
- If possible, visit the institution first and go over the route you plan to follow with your class.
- Ask the children for questions they would like to have answered by taking the trip. List them.
- If suitable, have committees of children take responsibility for particular problems to be investigated during the visit.
- Discuss conduct on the trip: materials needed (cameras, jars, notebooks, etc.), responsibilities, route (maps), behavior in subways and buses and in the resource agency, avoidance of hazards, courtesy, lunch time, etc. Let children play an important part in planning for the trip.
- Discuss conservation aspects: what may and may not be collected. Most resource agencies do not permit any collection at all.
- Secure all necessary parental permissions, clear with principal, arrange for transportation, arrange for teacher-aides from parents, set time schedule.
- Notify your school lunchroom if you will be away during the lunch period.

On The Trip

- Do not hurry the children too much. Don't try to "cover" too much.
- Encourage picture-taking where feasible.
- Allow time for lunch, rest and use of sanitary facilities.
- Plan the trip so that children are not so involved in note-taking (this applies particularly to museums) that they do not really observe, enjoy, participate, react.
- If there is a guide, gather children around before the guide starts to speak. Give children a chance to ask the guide questions.
- Remove living things only if permission has been obtained and if a suitable environment for those living things can be provided in the classroom. In general, it will be necessary to prepare the "home" in the classroom before the organism is brought back.
- Leave the area in a better state than when you arrived, if feasible. Clean up man-made debris.

After The Trip

- Have the class discuss their experiences.
- Have committees report their findings and arrange exhibits.
- Set aside a portion of the classroom for the display of pictures taken on trips.
- Relate experiences to science generalizations or concepts in the area of science studies.
- Ask: What did you enjoy most? Why?
  What didn't you enjoy? Why?
  What did you learn?
  What was most unusual?
  What questions were answered?
  What questions were not answered?
  What new questions came up?
  Would you like a return visit? Why?

- Have the class (or committee) write thank-you notes to persons responsible for assisting in the trip and in the presentations made.
- Don't make the visit to the resource agency the reason for a test. To do so may diminish the interest in the trip and the desire to take trips in the future.
- Encourage individual children to write prose or poetry, make sketches, conduct research projects inspired by the trip, etc.
- Share your experiences with other classes.

Useful References

See the following New York City Board of Education publications:

Guide to Science Trips and Environmental Resources in NYC
Adventures on the Beach-Teacher's Guide K-12
Operation New York: Using the Natural Environment

CHAPTER X

ACTIVITIES IN ENVIRONMENTAL SCIENCE

All living things interact with their environments and influence them in some way. In contrast to other living things, humans can, within limits, remodel their environment to suit themselves. As a result we can enjoy many comforts such as controlled temperature at home, water transported from hundreds of miles away, roads which lead through all kinds of terrain and vehicles that help us move freely and swiftly. As a result, however, we produce air pollution, water pollution, noise pollution and crowded, dirty cities. The lives of many species, including man, are endangered. The future looks bleak.

What can we do? How can we help to prevent this destruction of our environment? One answer is to involve our young people in activities which will make them aware of their environment, of their roles and responsibilities in keeping it safe from further plundering.

Students should be helped to discover the important relationships between man and his environment, to become aware of how carelessness and the unwise use of our natural resources can affect not only people but the many living and non-living factors in our environment.

This awareness can be developed by exploring the neighborhood and nearby areas to see the causes and effects of pollution. As the students explore, investigate, experiment, measure and interpret the records they keep, they will more fully understand their own relationship to their environment.

It is hoped that the students will develop:

1. A feeling of responsibility regarding their surroundings: the school, the home and neighborhood.

2. An appreciation for beauty. (Help students "Look for a thing of beauty.")

3. Understanding that living things are interesting in and of themselves. Students need experience with living things in and out of the classroom.

4. Feelings of kindness built on the understanding of the needs of plants and animals and the role of each in the food chains and in the web of life.

5. An awareness of the environment by:

    a. knowing the factors which make up a good neighborhood.
    b. establishing standards by which to judge the environment.
    c. knowing the conditions, laws, professions and processes that help to shape the environment.

Some General Suggested Activities

I. Interdependence of living things with their environments.

1. Set up different kinds of environments in the classroom, e.g., woodland terrarium, desert terrarium, an aquarium. Find out what the living and non-living factors in each kind of environment are.

2. Set up a home for insects. What will your kind of insect need to live? (Ants, mealworms, fruit flies, earthworms). How do these insects affect other living things? What are some insect pests? How do we get rid of insect pests? How does the use of DDT affect us?

3. How does crowding affect animal life? Grow brine shrimp in varying amounts of space. Keep records.

4. How does noise affect us? Can noise affect the growth and development of plants, of animals?

5. What kinds of environments can be found in your neighborhood? Make a map. Indicate the kinds of things found in each environment.

6. What little "environments" are there in your school yard?

II. Man changes the environment

What happens when the plant cover of land is removed?

A. Look for signs of erosion in the neighborhood.

1. Plan an activity to find out what happens when plant cover is removed. Fill two pans with soil. Plant grass seeds in one. Water the seeded pan regularly, until the grass grows and is about one inch tall. Then water each pan with two cups of water. What happens to the water? What happens to the soil? Which pan has more water running off? Collect the running-off water and measure the amount collected. In which pan did the water seep in most? From which pan was the soil washed away? Which pan had the clearest water? Why?

2. Discuss what happens when trees are cut down. Relate the above activities to large scale erosion where unwise practices have been used in clearing the land.

3. Why are plants necessary in the city? Make an inventory of the trees in your neighborhood. Find out who takes care of the trees.

B. Make a tree guide for the area around your school. Find out who plants the trees. Look for ways in which trees are protected. In what ways are trees injured? Plan a neighborhood campaign to keep trees from injury.

4. Set up an experiment to find out how leaves help keep soil moist. Have two pans of soil, one covered with leaves, one without leaves. Moisten both. Which will stay moist longest? Keep records.

5. Make a study of little environments near a tree:

   1. Under a tree
   2. On the trunk
   3. In the crown
   4. Around the roots.

C. How does man change the air?

   a. Find out what other things besides dust pollute the air. Write to the Bureau of Air Pollution Control. Invite a member of the bureau to speak to your class.

   b. Set up soot fall stations in various parts of the neighborhood. This can be done by using plastic containers. Pour water into the containers until each is about half full. Put one container at each place you select. Note the date. Examine the containers at intervals to record the amount of dust that falls out of the air.

   c. Find out how air pollution affects our health. Write to the city or state bureau of Air Pollution Control, the Health Department.

   d. Determine the cost of air pollution, the soiling and destruction of all kinds of materials and the enormous cost of cleaning materials. What methods can be used to prevent destruction of material by air pollution? Make a display of cleaning materials.

   e. Is there any relationship between the air pollution index and the amount of traffic? Keep records.

D. How does pollution of water affect living things?

   a. Find out the various ways in which our waters are being polluted. What happens to the animals and plants that live in waters that are polluted? Grow brine shrimp. Find out what conditions they need to live.

   b. Make an aquarium. What do the living things need to stay alive?

   c. Find out how drinking water is made pure.

   d. Study the life in pond water or water from an aquarium. How do these living things affect the other living things in their environment?

   e. Oil from tankers often leaks into oceans and large lakes. How does this oil affect the living things in this area? How can the oil be removed? Set up experiments with oil and water. Try different methods to get rid of the oil.

III. Conservation of Plant and Animal Life

a. What is man's role in the extinction or near-extinction of living things? (passenger pigeon, buffalo, bison, whooping crane). Write the State or Federal Department of Agriculture to find out what laws have been passed to protect our wildlife. Contact the A.S.P.C.A. and the Animal Medical Center (York Avenue, New York City) to find out what they are doing to protect animal life.

b. What is a wildlife sanctuary? Where are these sanctuaries? Write to U.S. Bureau of Fish and Wildlife Service, the National Audubon Society and the New York City Department of Parks. Visit the Jamaica Bay Wildlife Sanctuary.

c. Make a little sanctuary in your school area. Make a bird feeder and a bird bath. Place them where cats and squirrels cannot disturb them. Watch for the bird visitors. Try to keep record of the birds that come.

Suggested Topics for Grades K-6

Kindergarten

1. What lives in our school garden, in our lawn, in the park? Make exhibits, charts.
2. Sounds in our neighborhood; pleasant, unpleasant.

Grade 1

1. Animals in our neighborhood
   a. Animal pets
   b. Wild animals (birds, insects, squirrels)
   c. The pet shop
   d. Birds in our neighborhood
   e. Dogs in our neighborhood

Grade 2

1. Animal Pets - care of.
2. How animals grow - care of, needs of.
3. Needs of plants. Experiments with varying conditions of soil, water, light, temperature. Do plants in our neighborhood get what they need so they can grow well?
4. Where does our water come from? Where does it go?
5. Studies of soil in the neighborhood. What is in soil? Kinds of soil in our neighborhood.
6. Rocks in our neighborhood. Kinds of - natural, man-made. Make collections; study characteristics of. Note where they are found.
7. Can plants grow in sand, pebbles, soil? Set up experiments, make sure to have a control. Relate the results to the results of the growth of plants in the neighborhood.

Grade 3

1. Where do animals in our neighborhood live? What kinds of homes do animals need?
2. Growth experiments. What happens to plants in a city environment?
3. How trees are hurt in the city. Who takes care of the trees and parks? How can we help?
4. Make a guide of the rock materials in and around the school.
5. What materials are used to build a street?

Grade 4

1. Study of a street. How is it built? Of what is it made? How can we keep our streets clean?
2. What are the manhole covers for? (Conduct a study of how services ar made available in the city.)
3. Water. How do we get it? What are the uses of water? How is water purified? How can we conserve water?
4. What is under the street?
5. Kinds of sound - sources of.
6. Which materials carry sounds. Why do sounds seem louder in the city?
7. Tape different sounds.
8. How does sound pollution affect health?

Grades 5 and 6

1. Importance of trees in a city environment. Survey of trees in the neighborhood. Study of a particular tree. Make a map, tree guide. What happens to trees in a city environment?
2. "Little environments" in the neighborhood. Factors within each environment (lawn, park, pavement).

CHAPTER XI

EXPLORING THE SCHOOL AND ITS VICINITY

A student's education is not limited to that which takes place in school. Much of what is most meaningful and real to the student takes place outside school walls. If the role of education is to help students understand the world in which they live, then it is essential that we help students use the skills they learn inside the classroom to understand and interpret the world outside.

Short trips in and around the school can open up a whole new area of investigation and learning. The following sample questions or instructions can form the basis for such activities.

In the school

What rock materials were used to build the inside of the school?
How does water get into the building? How is it distributed?
Where are the pipes? What is a trap?
How is electricity used?
What are staircases built of? How many steps make a flight? Why?
How many flights? How wide is each step? Each riser?
How can you figure the height of each floor, using the dimensions of the steps?
How old is the school building?
What metals are used in the school?

The school building

What rock materials were used to build the outside of the school?

The street

What is the structure of the street?
Identify:

a. sidewalk - How long is each rectangle? How wide? What is the function of the cracks between rectangles?
b. road - What is the function of the crown? manholes? What materials are used in the construction of each?
crown, manholes, construction materials
c. gutter - What is the function of the gutter? Sewers?
d. curb - What materials are used in the construction of the curb? What is the function of the curb?

What is the reason for the material used in each part of the street?
How would you make a map of the street showing manholes?
What are the different purposes of manholes?

Plants

Street trees

What is the structure of a tree?
What are some of the characteristics of a tree? Describe the bark. leaves. flowers . fruit.
What types of injuries do trees sustain?
Observe and describe the shape of various trees?
How can the trees be protected against injuries?
How does the litter found around trees affect the tree's life and growth?

Other plants

Where do you see them? How do plants affect the street environment? How do they make you feel?

Rocks

Where are rocks seen? i.e. streets, buildings, etc.
What kinds of rocks do we find in the school environment?
Describe the uses of rocks?

Metals

What kinds? Use a magnet to aid identification.
Where are metals used?
How are metals used?

Animals

What kinds of animals do we find in the community?
Where are these animals seen?
What kinds of problems do animals present to our environment? What can we do to help control this problem?
Discuss possible solutions.

Construction work

What does the ground under the street look like?
What machinery is used in constructing streets?

Traffic

What kinds of vehicles are found in the streets?
How many vehicles are seen per minute? Chart results.
Describe the different types of noises heard from these vehicles?
What pollution problems do vehicles present?

Electricity

Where are the street lights? How far apart are they?
Describe the lighting devices in the neighborhood. Can the wiring be seen?
Where are the wires?
How does Con Edison help to play a part in the supply of electricity in New York?

Signs of change

What are the changes in roads? buildings? stair steps?
What are the changes in plant and animal life?
What caused these changes?

Shapes

What shapes can you see?

Numbers

Take a 10-minute walk. Keep a record of all the numerals you see and their uses.
What are some numerals, (in the street), that are important to you?

Beauty

What makes you smile? Feel good?
Describe some art forms (carvings, sculpture) in the environment.
What shapes do you see?
What colors do you see?

Stores

What kinds of stores are in the community?
How do they help the neighborhood?
How do they contribute to the litter problem? How could stores help in solving the litter problem?

Shapes of buildings

What are some of the different heights and widths of the buildings in our community?

CHAPTER XII

"THE CONSUMER IN CHELSEA"
(OR ANY OTHER NEIGHBORHOOD)

The topics suggested in this report are suitable for developing the theme "The Consumer in Chelsea." They have been planned to include the basic concepts and skills of the New York City science curriculum, grades K-5. The projects are based on exploration and the application and relationship of science concepts to daily living. Emphasis is focused on the integration of related curriculum areas such as reading, mathematics, social studies and art to the science program.

The definition of the term consumer can be taken, in its broadest sense, to mean the individual who uses or benefits from an object or relationship. It is suggested that the students be encouraged to take a close look at the neighborhood in which they live to find out the role science plays in their daily lives.

It is hoped that as a result of these activities, the students will be helped to discover the important relationships between man and the environment and to become aware of how carelessness and the unwise use of our natural resources can affect not only people but the many living and non-living factors in our environment.

A study of the role of the consumer in Chelsea should help the students to develop an awareness of and a feeling of responsibility to their surroundings and help them a) to understand the factors which make up a good neighborhood, b) know the conditions, laws, professions and processes that help to shape the environment, c) establish standards by which one can judge the environment, and d) realize the relationships of the consumer to his environment.

Suggested Projects

A. Science and Shopping

The Supermarket

What is the origin of foods and their relationship to cost (type of, source of)?

How are foods kept fresh (freezing, salting, drying, canning, wrapping)? Related experiments can be done.

How are foods packaged? Why are they packaged in different ways? Have the students try different methods and note the results. What is the relationship of the method of packaging to the cost of the product?

What kinds of machines are used in the supermarket (conveyors, ramps, wheels, scales, slicers, automatic doors, etc.)?

What do labels on foods tell us? Who decides what should be on the labels? Why?

How are foods measured? Why should we know this?

What are the different kinds of meat products in the supermarket? What is their origin? How are they packed? What units of measure are used? Why are some meats more expensive than others?

The Bakery

What kinds of bread are there?

What is bread made of (flour, kinds of flour)?

What makes bread rise (See Science: Grade 5 pp. 35-40.)?

How is the bread sold (unit of measure, packaging)?

What sanitary rules must be followed? Who decides what rules must be followed?

What is the role of the government in maintaining product standards?

The Fish Store

What kinds of sea food are sold?

Where does the sea food come from?

How is this kind of food obtained?

How does the sea food get to the local store?

What foods come from the ocean? What foods come from fresh water?

What kinds of workers are employed in this business?

How is the sea food prepared and packaged for us?

What is the anatomy of a fish? A snail? An octopus?

What are some favorite sea food recipes of different cultures?

The Pet Shop

What kinds of things are sold in a pet store?

Where are some of the living things found in nature?

How do we care for different kinds of pets?

What is the best food for each kind of pet? How are the different kinds of pet foods made? What are these foods made of? What does your pet eat?

What is the growth pattern of each kind of pet?

What are some of the interesting things your pet does?

What kinds of jobs do people in pet shops do?

B. Workers in the Neighborhood

What are some of the different kinds of jobs in the neighborhood (service performed, knowledge needed, employer)?

C. The Street

How is a street built? a) What are the materials that are used? b) What are the components of the street? c) What are the functions of each part of the street? d) What are the functions and locations of the sewers? e) What is the purpose of manholes? f) What is under the street?

How is a street cared for? What are the roles of the sanitation department? Other city agencies?

What makes a street dirty? How can we help to keep our streets clean?

What kinds of traffic do we find on the street? What are the effects of traffic on noise pollution? On erosion of the street? What city agencies control traffic? How do they control traffic?

D. Living Things in the Neighborhood

What kinds of living things are found in your neighborhood?

How do pigeons or dogs affect our lives and our environment? What kinds of problems do animals like these pose to our community?

What kinds of plants are in our neighborhood? How can we care for them? Why are they necessary?

What do animal pests need to live? How do they affect us? What can we do to control them?

What kinds of living things can we find in the park near the school? Why are parks necessary? Who takes care of the park?

E. Waste

What kind of wastes are there (solid, liquid)?

How are wastes disposed of?

What is recycling? What kinds of things are recycled? What are some examples of recycled products (paper, objects made from cans, old containers, cloth, etc.)?

F. Air Pollution

What are the causes of air pollution?

A possible experiment to show air pollution may include the following: set up soot fall stations, collect and analyze dust. What kinds of dust are there? What is the origin of this dust?

What laws have been made concerning air pollution (automobiles, buildings, etc.)? Follow-up activities may include visits to an air pollution control laboratory, speakers from EPA, etc.

What is the cost of air pollution to citizens in terms of health? Damage to buildings, etc.?

G. Water

What are the uses of water?

Where does our water come from?

Where is the nearest reservoir?

How is water polluted? What is the effect of polluted water on plants and animals?

How is water made safe for drinking?

H. Buildings

What kinds of buildings are found in Chelsea (or in the neighborhood studied)?

How are buildings damaged?

What materials are used to make these buildings? What materials were used to build our school? (Possible activities may include creating a guide, making bricks and concrete, making a neighborhood map, etc.)

I. Moving Things in Chelsea (Or Your Neighborhood)

How are things transported? What kinds of vehicles are used? What kinds of machines are used?

What are elevators? When are they used?

What are ramps? Why are they used?

How much traffic is there? Where? What kind?

How does this affect us (pollution, noise)? What are the good effects of traffic?

J. Sounds in the Neighborhood

How would you describe the sounds (pleasant, unpleasant)?

What causes each sound?

How do these sounds affect us?

What laws are made to protect us from unpleasant or unwanted sounds?

CHAPTER XIII

SCIENCE AND READING

Teachers in the elementary schools are faced with a dilemma. Despite all efforts, reading scores on the whole are below expected levels. On the one hand there is great pressure to teach reading. On the other hand there is a great need to teach science, to help our students become scientifically literate citizens who have an "environmental ethic." Our culture is based in large part on science and technology. If students are to understand themselves and their culture they must have the necessary scientific information to do this. They must also have the knowledge and skills to correctly interpret information they receive and to make intelligent judgments and decisions.

The teacher, faced with the reality of a heavy daily schedule and the pressure to teach reading will often omit science altogether or give it token time in his or her daily plan. It is needless to say that a program top-heavy in reading activities with the main emphasis on reading skills rather than content and relevance becomes boring, tedious and often meaningless to the student.

Student are naturally curious, inquisitive and eager to investigate the world around them. Science is fascinating to most students. They love to explore, experiment and discover. Why not use science as a vehicle for teaching reading? It is through experiences with real things, with the concrete, that students develop an apperceptive base for understanding concepts and the symbols of the printed page. The dilemma presented by the demands of both reading and science for classroom time can be resolved. Reading activities can be motivated and reinforced through an inquiry-type science program.

Reading consists mainly of the decoding of written words and comprehension of written materials. As a result of decoding, the reader learns the sound of the words, but not their meanings. Decoding is accomplished mainly by means of phonics. Decoding is often regarded as the main reading skill, especially in the primary grades. The student who pronounces all the words correctly during oral reading is often considered a good reader, yet that student may have little or no understanding of what was read. Comprehension of the meaning of written material is the main goal of reading. Decoding is merely a step toward comprehension.

Comprehension of written material is the understanding of the correspondence of written symbols (words, sentences, paragraphs, etc.) to actual objects, characteristics, feeling, situations and so forth. The study of science can do much to promote comprehension. At the same time it helps students to improve their decoding skills by providing additional opportunities to read and motivating them to do so.

An analysis of current elementary science curricula (particularly New York City's science curriculum) shows that these are based on problem solving through first hand experiences. Science skills or processes are used to make science investigations. These are some of the skills most often used in inquiry focused programs: asking questions, predicting, observing, classifying, measuring, keeping records, and generalizing. Practice in the use of these skills helps students to develop the ability to solve problems and to think logically and critically. When students are involved in inquiry type activities they utilize the above skills to help them discover the information they need to answer their questions.

A close look at both reading activities and science activities shows a similarity and close relationship between the skills of reading and those of the science program. In both areas the development of concepts is based on experiences and the mastering of the skills. Many reading programs make reference to science activities as a means for developing reading skills. A large number of readers contain stories and exercises based on scientific information. The reason for this is to help students build up a store of information so that they can form concepts and understandings of the world in which they live. Examine your reading materials and see how many activities include science information.

There is no question that the development of science skills can help students to read. While you are teaching science you can motivate interest in reading and reinforce reading skills. Here are some ways.

Observing is an important science skill. The students discover the characteristics of their environment by using all their senses. Science activites focusing on the skills of observation can reinforce the reading skills of auditory and visual discrimination. What are the different sounds around us? What sounds do animals make? How are sounds made? Activities which help the student note differences in size, shape, color, or texture encourage noting of details and help develop the ability to classify and identify objects according to their characteristics. While students are discovering, they should be encouraged to communicate and to discuss their experiences, thus enlarging their oral vocabularies and listening skills. Playing records and using radio and television programs in science can help reinforce this area also.

Comprehension is based on many experiences with real materials and activities which help build a body of information. Investigating and experimenting help to build concepts. Investigation in which records are kept helps students to understand relationships and draw inferences, e.g. keeping records of growth of plants under different conditions, making maps of the neighborhood, surveys of resources, keeping weather records, pet diaries.

Building a sight vocabulary is best accomplished by using concrete words. These words are easier and more useful to learn on the early levels of reading than the abstract words. In science activities, students can name and classify objects. Labels of plants, animals, rocks, or tools help students learn to read specific words. Experience charts based on science activities are very helpful in building sight vocabulary.

When students become involved in investigations, they often find it necessary to obtain information (e.g. How to build a weather station ? How to care for a class pet? How to make an insect cage? Where can fossills be found?). This encourages the use of research and library skills. In the development of a science unit, the students might help set up a collection of books on a specific topic or develop their own bibliographies.

An essential skill in science is keeping records. When students keep records of their experiments and investigations they reinforce several reading skills. Examples of records which can be kept include those dealing with the weather, ages of students, growth of plants, changes that occur with different chemicals, phases of the moon, change in length of daylight hours. The interpretation of these records is also an important skill and is closely allied to similar skills in reading.

When students work in the area of science, their knowledge of technical words develops. As they investigate and work with concrete materials, their understanding of the meaning of words grows. When they read labels, experience charts and books, keep records and diaries, their ability to recognize words grows, too. As their oral and sight word vocabulary grows from experience, their ability to read and comprehend increases as well.

There is no question that students learn better and faster when they are interested and have a need to find out. A stimulating science program can provide this interest and purpose. At the same time the very nature of science investigation can serve to reinforce basic reading skills. There should and can be time for science. It is possible to "kill two birds with one stone." While you are involving students in science they are also improving their reading.

CHAPTER XIV

TEXTBOOK REVIEW

Introduction

The following sections, Textbook Review and Analysis of Book, are included in our staff development program guide to help you analyse new elementary science textbooks for use by your school or district.

They will be of great help to any supervisor, teacher or science committee in making rational decisions concerning textbook selection.

The book Sciencing[1] by Cain and Evans has an excellent chapter, "Textbook Approach to Elementary Science," listing and analyzing the strengths and weaknesses of the textbook approach in teaching elementary science.

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[1] Sandra Cain and Jack Evans, Sciencing - An Involvement Approach to Elementary Science Methods (New York: Charles E. Merrill, 1979).

Textbook Review

Overall Textbook Rating:

Publisher:

Title and Grade Level:

1. Examine the front matter (preface, introduction, contents, etc.) of the textbook.

    a. What is the copyright date?

    b. What are (or seem to be) the overall goals of the textbook?

    c. Describe and give examples of the organization of the textbook. (Is it organized in single lessons? Topic form? Units? etc.)

2. Examine several specific lessons.

    a. Describe the typical lesson format.

    b. Identify the main kinds of materials suggested for use with the lessons.

    c. What kinds of objectives are indicated for the lessons? Give examples.

    d. Describe evaluation techniques suggested.

    e. Your comments. (Any unique features? etc.)

Rating Scale

0 - Book totally lacking in the characteristic
1 - Occasional evidence of the characteristic
2 - Evidence of the characteristic but below average
3 - Frequent evidence of the characteristic
4 - Excellent evidence of the characteristic
5 - Superior in all aspects of the characteristic

CRITERIA FOR RATING TEXTBOOK	Names of Series Reviewed	
APPEARANCES 1. Physical qualities attractive and appealing to students		
2. Margins and page arrangements contribute to readability and attractiveness		
3. Adequate spacing and appropriate type size		
4. Suitable size for easy handling		
5. Durable backings		
6. Good quality paper		
7. Illustrations contribute to meaning of the content		
8. Appropriate page layout - students can easily follow the sentences		
9. Type size and style easy to read		
CONTENT 1. Develops problem-solving skills		
2. Scientifically accurate and up-to-date		
3. Appropriate for the developmental level of student		
4. Analogies and activities appropriate		
5. Follows a logical sequence		
6. Develops positive attitudes toward science		
7. Suggested lessons stimulate interest that will lead to further study		

	Names of Series Reviewed	
CRITERIA FOR RATING TEXTBOOK (Continued)		
8. Provides for various ability levels (the nonverbal student, the student with reading problems, the high achiever, etc.)		
9. Well balanced in terms of scientific content		
10. Central theme clearly defined		
11. Free from anthropomorphism, teleology, and personification (attributing human form, qualities, purpose, or will to nonhuman things)		
12. Usable index and table of contents		
13. Glossary of science terms and clearly stated explanations of meanings		
14. Free from sex bias		
15. Suggestions for treatment of controversial materials		
PRESENTATION OF MATERIAL 1. Has a clearly defined teaching strategy		
2. Stimulates class discussion		
3. Uses divergent as well as convergent questioning		
4. Encourages students to do experiments		
5. Material presented in an interesting manner		
6. Includes mathematics in the experiments and activities		
7. Offers suggestions for using mathematics		

CRITERIA FOR RATING TEXTBOOK (Continued)	Names of Series Reviewed	
TEACHER'S GUIDE 1. Offers alternative activities		
2. Gives necessary background information for effective use of textbook material		
3. Suggests teaching aids, games, etc.		
4. Lists resources (printed, visual, audiovisual, etc.)		
5. Suggests remedial and/or enrichment activities		
6. Suggests a variety of evaluation techniques		
7. Offers help in planning and implementing text material		
Total points for textbook (225 possible)		

Analysis of Book

Title______________________________ Grade Level________

Author(s)______________________________

Publisher______________________________

Copyright date__________ Revision dates______________________________

Student's Section

Contents - major areas covered______________________________

Number of chapters_____ Number of pages in average chapter______________

End of chapter activities - Types______________________________

What attempts are made to reinforce reading?______________________________

Illustrations - kinds ( ) photographs ( ) paintings or drawings
( ) diagrams

Readability level - Is it suited to the grade for which it is written?
( ) yes ( ) no

Teacher's Guide

Philosophy of the program______________________________

Background information

Pedagogy______________________________

Science______________________________

References - ( ) Bibliography ( ) Audio-visual ( ) Supply houses

Value of teacher's guide to you - In what ways is it helpful?

CHAPTER XV

ELEMENTARY SCIENCE NEEDS-ASSESSMENT

Introduction

No science program in the elementary school will be implemented unless the staff of the specific school and or district evaluate their current science program and set realistic goals for science instruction in the future.

Below is a suggested Elementary Science Needs-Assessment which should be used by supervisors and teachers to help them evaluate their current elementary science instructional program. The questions were chosen to raise staff consciousness about those components which we feel are important to a sound elementary science instructional program.

We have left the needs assessment open ended so that other areas of importance that your staff feels could enhance their science program can be added.

This assessment is meant to set the stage for a supervisor and or a school science committee to begin serious planning for an ongoing science program which will insure that the New York City science curriculum is implemented.

Elementary Science Needs-Assessment

Name

School District

Position in school or district

(Please circle the appropriate responses.)

1. Are the minimum essentials in science taught in your school?	Yes	No
2. If your answer to #1 is No, what do you think the reasons are?		
a. Lack of trained staff	Yes	No
b. Insufficient supplies	Yes	No
c. No science texts	Yes	No
d. Overemphasis on other subject areas	Yes	No
e. Not enough time	Yes	No
f. Lack of science supervision	Yes	No
g. Other reasons - please list		

____

____

____

3. Does your school have a supervisor or staff member who is directly responsible for science?	Yes	No
4. Are science lessons observed regularly by your school's supervisor?	Yes	No

5. How is professional development in science education encouraged?

a. In school ______________________________

____

____

b. In district ______________________________

____

____

6. Is a science materials inventory maintained in your school? Yes No

7. Are school/district funds allocated for science texts and supplies? Yes No

8. What other funding resources are available to your school for science materials?

a. P.T.A. Yes No

b. Mini grants Yes No

c. Individual parents Yes No

d. Community Yes No

e. Other - please list.

____

____

9. Does your school or district have an established science resource center? Yes No

10. Is there space available for science resource center in your school? Yes No

11. What other needs do you perceive as necessary to improve science education in your school or district?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

12. What methods are used to evaluate student progress in science?

a. In your school____

b. In your district____

CHAPTER XVI

ELEMENTARY SUPERVISORS FOLLOW-UP SUGGESTIONS

Introduction

Below is a list of follow-up suggestions which our staff feels will help all science supervisors to improve the science instructional programs within their schools.

We invite all supervisors to add to this listing and share their ideas with us during the training progam.

Elementary Supervisors Follow-Up Suggestions

A. Evaluate the science program within your realm of responsibility.

B. Insist on inclusion of science lesson plans from all classroom teachers within your realm of supervision.

C. Observe science lessons.

D. Develop methods of evaluating student science progress which aid and foster your instructional planning and instructonal program.

E. Encourage sharing of science methodology at staff conferences.

F. Plan a specific program for implementation of an improved science program (with active participation of a school or district science committee).

G. Use a performance planning approach to implement this plan.

1. Establish school goals in science.

2. Define specific objectives for the following personnel:

    a. supervisor
    b. staff
    c. students
    d. parents

3. Develop a strategy for implementation which contains the following elements:

    a. what tasks are to be performed
    b. how will they be performed
    c. when will the task(s) be performed (specific time frame)
    d. who will perform the task
    e. what resources will be allocated for the accomplishment of the task

H. Stimulate the professional development of those staff members interested in science education by:

1. encouraging membership in professional organizations.
2. encouraging participation of staff in city-wide science meetings.
3. upgrading professional library with current materials relevant to science education.
4. channeling current science methodology materials to interested staff members.

I. Raise funds for science.

J. Encourage the organization of a science resource center.

K. Give science demonstration lessons yourself or invite district staff to do so.

L. Encourage school-wide activities, e.g. science fair, science institute, etc.

M. Others - Please list and share your ideas with us during the training sessions.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

1. Goal - is a continuous purpose that provides a sense of direction through time.

2. Objective - is a measurable desired result to be accomplished within a specified time period.

3. Strategy - an action designed to assist in meeting the objective.

4. Task - activities that collectively form the strategy.

NOTE: This list is excerpted from a "Guide to Performance Planning" prepared by the Board of Education of the City of New York.

CHAPTER XVII

RESOURCES FOR IMPROVING SCIENCE INSTRUCTION

Good elementary science means well planned hands-on experiences for young students. This means you have to know where to get materials, supplies and activities. I have found the best way to do this is to get myself "networked" into the N.Y.C. science teaching community. Below I have listed those N.Y.C. resources which have helped me get involved. Through using these resources I have been able to plan better, to obtain materials and to grow as a professional science educator. This listing is by no means complete. It is compiled to help you get started and to give you new avenues to help improve already existing programs.

I. CURRICULUM:

New York City Board of Education - Office of Curriculum Development and Support
Publications Sales Office
Rm 136
110 Livingston St.
Brooklyn, N.Y. 11201

Catalog of Curriculum Publications
Curriculum Bulletins:
Science: Grades K-2, Science: Grades 3-4, Science: Grade 5, Science: Grade 6.
Science Trips- Guide, Environmental Resources in New York City
Adventures on the Beach - Teacher's Guide K-12
Science Safety K-12

II. PROFESSIONAL ORGANIZATIONS:

There are many professional organizations in the New York City area ready, willing and able to help you to do better job as a science teacher in the elementary school.

A. Elementary School Science Association - E.S.S.A.
82-40 42 Street
Bellerose, N.Y. 11426

This group holds regular meetings, trips and sends out helpful newsletters.

B. Science Council of New York - SCONYC

Holds an outstanding science convention in New York City every March. By joining ESSA or one of the other junior high school or high school organizations you get information on the convention.

C. Staten Island Science Teachers Association - SISTA
New Dorp H.S.
Att. D. Buegler

D. New York State Marine Ed. Association - NYSMEA
Box 705
Mineola N.Y. 11501

E. New York State Science Supervisors Association
M.R. Aaron
Lawrence Public Schools
Cederhurst N.Y. 11516

F. Science Teachers Association of New York State - STANYS
7 Town Ridge Ave.
Albany, New York 12208

G. National Science Teacher Association - NSTA
742 Connecticut Avenue N.V.
Washington, D.C. 20009

Holds a National Convention and publishes outstanding magazines one of which is Science and Children

H. New York Academy of Science - Education Section
2 East 63 Street
New York, New York

Holds monthly meetings on science education topics.

III. SCIENCE SUPPLIES AND MATERIALS

A. New York City Board of Education - Bureau of Supplies - Science Section

Their bulletin, listing supplies that may be ordered by elementary schools, is available in all schools.

B. N.S.T.A. Directory

NSTA has produced a publication called Directory of Science Education Supplies. It is one of the most comprehensive listings of suppliers and publishers of science education materials.

C. Salvage Sources for Science Materials

Resourceful teachers know how to compensate for tight equipment budgets. They scout the community for discarded materials that can be put to use in their classrooms. They also depend upon personal ingenuity to devise even better substitutes than the standard equipment they might ordinarily use in their lessons. The following is a list of possible sources of salvage materials that may be of use as science equipment.

1. Clinical medical laboratories
2. Dress shops or drapery shops
3. Electric motor repair shops
4. Grocery stores
5. Photography studios
6. Retail shops of all sorts
7. Shoe stores
8. Telephone installation crews
9. Toy stores

Don't overlook your students and their parents. They are most willing and generally able to donate materials to the school science program.

IV. OTHER RESOURCES

New York City is rich in resources for improving science programs. You can get materials from offices, industries, private and public agencies, for use as supplies for experiments, models and demonstrations. Films, pamphlets and many other instructional aids may also be obtained at little cost. In addition you can use various organizations as sites for field trips and as sources of guest speakers.

First plan, then consult your local telephone directory. See what groups might help you. Below is a sample list of typical groups that can be of help. They were selected because of their relevance to three topics of current interest in science.

A. Energy Education

1. National Energy Information Center EJ-20
   Room 1F-048 Forrestal Building
   1000 Independence Ave. S.W.
   Washington D.C. 20585
2. The Conservation Center - Consolidated Edison - 599-3435
3. The Energy Museum - Consolidated Edison - 460-6244

B. Environmental Studies

1. Parks Council - 838-9410

2. Prospect Park Environmental Center - 636-1900

3. Urban Park Rangers (all boroughs) - 822-4336

4. Wave Hill Center - 549-2055

5. Alley Pond Environmental Center - 229-4000

6. American Museum of Natural History - 873-4225

7. All Botanical Gardens

8. New York Zoological Society

9. Council on the Environment of New York City - 566-0990

C. Computers In Science

Computer and Information Science Unit
New York City Board of Education
131 Livingston Street
Brooklyn, N.Y. 11201

Association of Computer Educators - 648-7185

V. PERIODICAL LITERATURE & NEWSPAPERS

A. During the last two years the print media have produced a host of new magazines which highlight developments in science and technology. Don't overlook them for ideas, discussion topics and current background information. There are also periodicals designed specifically for science teachers.

A valuable reference to such periodicals is Periodical Literature for Science Teachers and Their Students. This reference is listed in the NSTA publication, 2nd Source Book for Science Supervisors.

Some pertinent periodical titles are:

1. The Science Teacher
2. Journal of Research in Science Teaching
3. Science & Children
4. School Science & Mathematics
5. Sky & Telescope
6. Natural History
7. Science Digest

37

CHAPTER XVIII

SCIENCE FAIRS

Suggestions for the Organization and Implementation of Elementary School Science Fairs

The elementary school science fair is an exhibition of the thinking and work of our students in the field of science. It should not be a competition. It should:

a. serve as a culmination of group investigations and explorations carried on throughout the year;
b. provide an opportunity for classes of students to pursue some topics in greater depth, and in a more open-ended way than is usually possible;
c. provide for individual exploration of personal interests in science.

One especially significant aspect of the school science fair is the opportunity it gives students to put into practice what they have learned throughout the year concerning methods of scientific thinking and problem solving. Through participation with the class in the preparation of a project for the school fair, the elementary school student learns, under his teacher's guidance, how to delineate a problem, design controlled experiments, keep accurate records and report his findings in an interesting and meaningful way.

In implementing the school science fair the services of the district science coordinator are available to all principals on request.

Suggestions for Science Fair Procedures

I Initial Steps

1. The assignment of the responsibility for implementing the science fair program can be placed in the hands of the school science coordinator, a science O.T.P. or a cluster teacher. The first task will be the organization of a school science fair committee. This committee may include representatives from each grade, and interested parents. The committee's responsibility is not only decision and policy making, but may also include specific assignments which relate to the organization of the fair.

2. The science fair committee and the coordinator will determine:

   a. Where the fair will be held (library, gymnasium, auditorium, special classroom, cafeteria).
   b. The theme of the fair - one area, e.g., Living Things, Electricity, Consumer in Chelsea (or any other neighborhood). An individual choice of subject may serve as a theme.
   c. How large the fair will be (based on limitations of facilities).
   d. How exhibits will be selected for the school-wide fair, for example:
      1. Only class projects.
      2. Class projects and a few individual projects.
      3. Class projects and all applicants with individual projects.
      4. Class projects and selected individual projects.

e. When the fair will be held. (This will reflect the policy of the science committee in terms of answering such questions:
   - Will the fair be scheduled to precede the district fair?
   - Will the fair reflect a culminating science activity?
   - Should an additional time be set to enable parents to view the exhibits?

II Science Fair Publicity

Another important functon of the science fair commmittee is to assist the coordinator in generating interest and enthusiasm among the pupils and teachers. Some of the methods to stimulate interest are:

1. Announce the fair at assembly programs, over the public address system and in classrooms.
2. Encourage preparation of pupil-made posters and displays for bulletin boards.
3. Prepare suitable news releases for the school newspaper or civic newspapers.
4. Organize assembly programs in which former science fair exhibitors display and explain their projects and suggest new areas for investigation.
5. Display past science fair projects in suitable areas. (Provide for security of the projects.)
6. Publicize the science fair by distributing posters to stores and banks in the neighborhood.
7. Invite parent, professional and civic organizations to attend the fair as visitors.
8. Invite the parent association to assist in various activities such as proctoring, acting as guides and providing security.
9. Invite representatives from the district office and nearby schools.

III The School Science Fair Circular

1. Well in advance of the science fair, work with your committee in developing a science fair circular to be distributed to all teachers. The information contained in this circular should advise teachers regarding:
   a. Due dates for returning the title of the class project;
   b. Due date for returning individual applications;
   c. Dates for classroom science fairs if they are to be held;
   d. Dates, location time for the school-wide science fairs.

2. Teachers will require guidance in the selection, organization and construction of a suitable project. Your circular, therefore, should contain suggestions on how to find and select a project area and what books and publications to examine (ex. textbooks, trade books, "Nature and Science," etc.). Pupils should be encouraged to use the school and public libraries as sources of research. Arrangements should be made for teachers to consult the school science fair committee and the district science coordinator.

3. In your suggestions to teachers and pupils regarding selection of projects, you should stress the following:

   a. Pupils should avoid selecting esoteric or highly technical project areas which are beyond their abilities or which require an inordinate amount of time, research and equipment not easily or inexpensively obtainable.
   b. Pupils must be instructed to consult frequently with their teachers in the selection of a project topic, in the organization and delineation of the project problems, and in the actual construction of the project. It may be advisable to include suitable checklist items and check dates in the pupil application form requiring the sponsoring teacher's signature. This may serve as an effective step by step control and will guide the pupils in the development of the project.

4. A section of the circular might be devoted to providing teachers and pupils with specific instructions in setting up the project for exhibition. In this area, our committee should establish uniform standards regarding:

   a. Use of construction material, exhibit panels, etc.
   b. Maximum size of exhibit (ex. 24" x 24").
   c. Labeling procedures.
   d. Identification cards.
   e. Use of photographs, diagrams, data reports.
   f. Use of heating device, electrical requirements, water.
   g. Use of chemicals.
   h. Humane care and treatment of animals.
   i. How to request information from professional scientists, scientific and industrial organizations offering bulletins or advice.

5. The Science Fair Application

   A science fair project application form should be part of the circular. It may be added as a separate form or added to the end of the circular as a tear-off stub. Whichever form is used, it should call for information which will be useful to the committee in organizing the fair and in selecting exhibitors. It should include:

   a. Name, class, teacher.
   b. Title of project and brief description of what the project will show or explain.
   c. Description of materials to be used and accessories (electricity, water, heat, etc.) required.
   d. Names of other students working on the project.
   e. Provision for a statement of approval by parent.

   In addition to the above, it may also be advisable to include check-points to be signed by the sponsoring teacher. This encourages pupil consultations with the teacher regarding the project and prevents pupils from undertaking projects beyond their understanding or ability to buy the equipment.

6. Project Suggestions

Teachers and pupils require help in the selection of a suitable project area for research or development. Often, the inspection of a list of provocative and imaginative titles suitable for a science fair project may trigger many ideas which will stimulate and arouse pupil interest. Ideas can stem from previous experiments which lead to questions such as:

- What would happen if we used this instead of that?
- What would happen if we did this instead of that?
- Why might our experiment have failed?
- What might have caused.....to happen?

The attachment of a list of titles or research areas to the circular distributed to pupils will materially assist and encourage pupil participation. Coupled with the other motivational activities suggested previously (assemblies, science displays, etc.), this will expose the pupils to many ideas to help them plan and organize their projects. Such lists of suggestions may be organized in groups reflecting the various science disciplines or topic heading. A varied list of titles representing a broad range of abilities would serve to encourage more students.

IV Additional Preparations

A complete and thorough preparation for a science fair involves many additional considerations which the coordinator must take into account. They include the following:

1. Security for the exhibits in the exhibit center.
2. Assignment schedules of school personnel, aides, etc., in proctoring exhibit area and adjacent corridors.
3. Provisions for electricity, heat, water where needed.
4. Providing assistance for minor repairs to projects.
5. Scheduling of class visits to exhibit area.
6. Provisions for parent visits, including letters of invitation.
7. Pupil guides and monitorial assignments.
8. Signs, monitorial badges, exhibit area decorations.
9. Removal of exhibits.
10. Evaluation of the science fair program and planning changes for the following year.

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APPENDICES

What Research Says

This column for elementary through junior high school teachers presents reports on important research in science education. Researchers are encouraged to send examples of their findings along with suggestions for classroom use to Mary Budd Rowe, College of Education, University of Florida, Gainesville, Florida 32601.

How Much Elementary Science Is Really Being Taught?

Patricia C. Manning
William K. Esler
J. Robert Baird

The amount, if not the quality, of science teaching in elementary schools is declining. (1,2,3)* The back-to-basics movement demands increases in instructional time to teach reading, mathematics, and language arts. This emphasis inevitably reduces the time available for other subjects, including science, in the elementary school curriculum. Determining the actual time spent in science instruction and the nature of that instruction is sometimes an elusive goal. In the past, surveys of school principals have proved unreliable. Perhaps because many elementary school principals either lack real knowledge of what is taking place in their classrooms or want to protect the image of their schools, survey results are at odds with the experience of knowledgable observers.(4)

We decided to study the status of science instruction in the elementary schools of Central Florida by administering a questionnaire to teachers enrolled in masters-level education courses at the University of Central Florida during the summer and fall of 1981. We received responses from 171 female and 20 male elementary school teachers in a six-county Central Florida region. These teachers represent a cross section of elementary teachers in the region, exhibiting a wide range of ages, teaching experiences, grade levels, and school sizes.

Teacher Preparation

As reported in Table 1, 12 percent of the responding teachers had taken no college-level courses in science content before beginning their masters program. Twenty percent had never had a science methods course; and 65 percent had never attended an inservice seminar on science teaching. This means that as many as 12 percent of these teachers had no preparation of *any kind* to teach science.

A core of teachers did respond, however, who were reasonably prepared to teach science. More than 40 percent had at least three college courses in science content, about 17 percent had at least three science methods courses, and 9 percent had attended at least three inservice science seminars.

Attitudes Toward Science

The questionnaire asked teachers to rate their confidence to teach elementary science competently. (See Table 2.) Levels among responding teachers vary from those who rank their confidence as very low to those who rank it high. Only 19 percent rate their confidence as above average, while 32 percent rate their confidence as below average.

Teachers were also asked to rank their preference for teaching science, reading, math, social studies, and language arts. Only 4 percent of the teachers rank science first in order of preference. More than 50 percent rank science fourth or fifth among the five subjects.

Nearly 25 percent of the teachers who responded said they spend *no time at all* teaching science in their classrooms; more than 75 percent spend only two hours or less per week. (See Table 3.) About 70 percent report they spend one hour or less of class time per week at activities in which students manipulate materials.

Preparation and Practices

Highly significant relationships exist between teachers' preparation and their practices and attitudes toward science. The number of science content and methods courses and inservice seminars teachers had attended correlates positively with the time they spend on science, their confidence levels, and their preferences for teaching science. (See Table 4.) Only the relationship between science methods courses and

Table 1.

Preparation To Teach Science
1981 Survey of Elementary School Teachers in Central Florida

	Number of Courses Taken				
Type of Course	0	1	2	3	4 or more
Science Content					
# Teachers	23	35	50	41	42
Percentage	12.0	18.0	26.2	21.5	22.0
Science Methods					
# Teachers	38	66	55	21	11
Percentage	19.9	34.6	28.8	11.0	5.8
Inservice Seminar					
# Teachers	124	31	17	6	11
Percentage	64.9	16.2	18.9	3.1	5.8

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*See References.

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Table 2.

Attitudes Toward Teaching Science

1981 Survey of Elementary School Teachers in Central Florida

Teachers' Confidence in Their Ability To Teach Science

Response	No response	Very low	Low	Average	Mod. high	High
# Teachers	3	20	41	91	24	12
Percentage	1.6	10.5	21.5	47.6	12.6	6.3

Preference for Teaching Science

Response	No preference	First	Second	Third	Fourth	Fifth
# Teachers	4	8	21	59	34	45
Percentage	2.1	4.2	11.0	30.9	28.3	23.6

Table 3.

Time Spent on Classroom Science

1981 Survey of Elementary School Teachers in Central Florida

Time Spent Teaching Science

Hours Per Week	0	1	2	3	4 or more
# Teachers	46	46	54	27	18
Percentage	24.1	24.1	28.3	14.1	9.4

Time Spent Manipulating Materials

Hours Per Week	0	1-2	2-3	3-4	4 or more
# Teachers	64	71	31	31	11
Percentage	33.5	37.2	16.2	16.2	5.8

teaching preferences was not statistically significant.

Survey Indications

The responses to our questionnaire indicate that levels of preparation for teaching science (measured by the number of science content and method courses and inservice seminars attended) are inadequate. This lack is accompanied by a lack of self-confidence among teachers in their ability to teach science competently and by their low preference for teaching it.

The attitudes are clearly manifested in their teaching practices. Nearly 25 percent report teaching *no science* and about 75 percent teach only two hours or less of science per week. These data paint a bleak picture for elementary science instruction in Central Florida. If this situation is being repeated in other regions of the state and nation, it is a sobering commentary on the amount and quality of science instruction that children are experiencing in elementary school.

It is not clear whether interested elementary science teachers take more courses and therefore are better prepared to teach the subject, or, having taken the courses, they become more competent. Even without clear cause and effect, it is abundantly evident that without additional professional preparation, teachers' attitudes and practices toward science education will not improve.

Table 4.

Relationship Between Science Preparation and Teaching Attitudes and Practices

1981 Survey of Elementary School Teachers in Central Florida

	Time Spent Per Week		Rank	
Courses	Manipulating Materials	Teaching Science	Teaching Preference	Confidence Level
Content	.001*	.001	.01	.001
Methods	.01	.01	(n.s.)	.001
In-Service	.001	.001	.05	.001

*The smaller the value, the smaller the chance that the relationship is coincidental. Only values less than or equal to .05 are considered statistically significant and therefore indicate interdependence of two variables.

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1. Hiatt, Diana B. "Time Allocation in the Classroom: Is Instruction Being Short-Changed?" *Phi Delta Kappan*, 61(4):289-90.
2. Denham, Carolyn, and Ann Lieberman. "Time To Learn." California Commission for Teacher Preparation and Licensing. U.S. Department of Education, Washington, DC. May 1980.
3. Gerlovich, Jack, Gary Downs, and George Magrane. "How Essential Is Science at the Elementary Level?" *Science and Children*, 19(3):22-24; November/December 1981.
4. Esler, W.K., John Armstrong, and Charles Dziuban. "Science Teaching in Florida's Elementary Schools." Journal of Florida Academy of Science. 1976.

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APPENDIX B-1

PARALLEL AND SERIES CIRCUITS

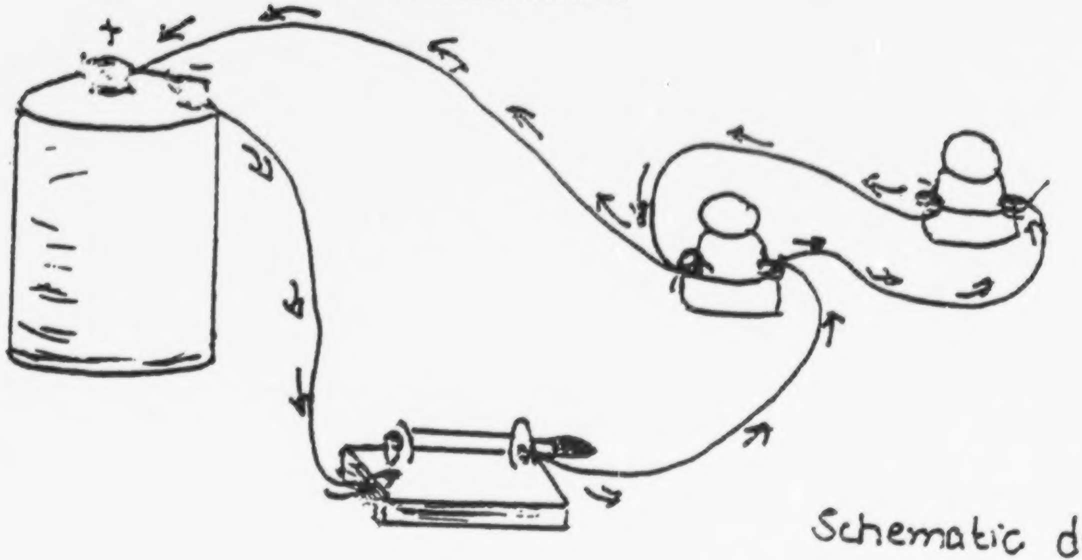
Check the Circuit

Each phrase below describes either a parallel circuit or a series circuit. Which one is it? Put a check (✓) in the proper box.

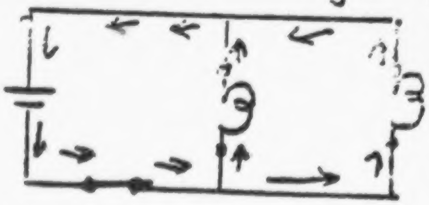
	Parallel Circuit	Series Circuit
1. Only one path for the electricity to flow		
2. More than one path for electricity to flow		
3. Loads work or shut off one at a time		
4. All loads are on or all loads are off		
5. Appliances share the voltage		
6. Applicances do not share the voltage		
7. Good way to wire a house		
8. Not a good way to wire a house		
9. An extra bulb makes the others less bright		
10. An extra bulb does not change the brightness of the others		

CIRCUIT DIAGRAMS

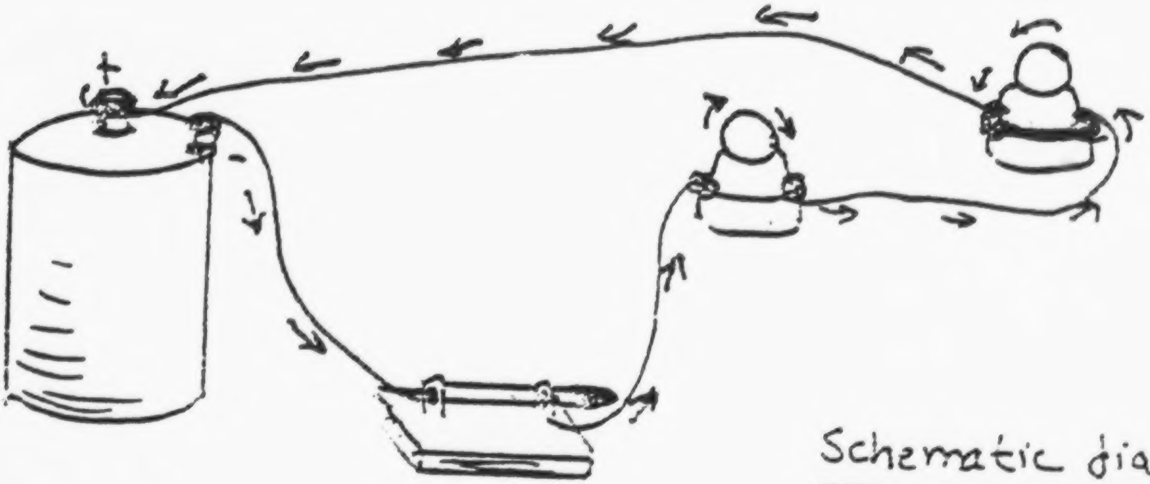
Parallel Circuit



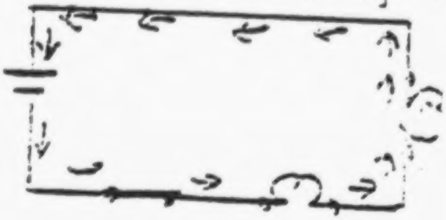
Schematic diagram



Series Circuit



Schematic diagram



APPENDIX B-2

BEHAVIOR OF MEALWORMS[1]

The realm of insects is a fascinating world to study. Insects have many interesting and exacting patterns of living which, when understood, can furnish information that can be used in helping to understand animal behavior. Bees, for example, have a pattern of life which is nearly a culture. Each bee has its role and when that role is fulfilled, it dies. There are many similar examples in the insect world.

Before anything can be determined about the specific behavior of an organism itself, information must be available about the organism. What does it look like? How does it move? What type of food does it eat? After such questions as these are discovered, specific hypotheses can be advanced and tested about the specialized behavior of the organism.

In this lab you are going to work with an organism called a mealworm. The mealworm is the larva stage of a beetle (Tenebrio molitor). It is reasonably good sized, active, manageable and quite a good subject with which to experiment. Some questions are suggested for you to experiment while on your own and test some of your questions.

1. Does a mealworm turn more often to the right or more often to the left?
2. Can you make a mealworm go in a straight line?
3. How far does a mealworm go in a minute?
4. How fast can the fastest mealworm go?
5. If placed on a slant, do mealworms walk up more than they walk down?
6. Can mealworms see?
7. How does a mealworm find food?
8. Do mealworms prefer a certain color?
9. How many ways can you make a mealworm back up? (17 ways is the current record).
10. How do mealworms "explore" a container?
11. Can a mealworm learn anything?
12. How does a mealworm work on the moving turntable of a record player?

---

[1] Elementary Science Study, Behavior of Mealworms (New York: Webster Division, McGraw-Hill).

METAMORPHOSIS OF THE MEALWORM

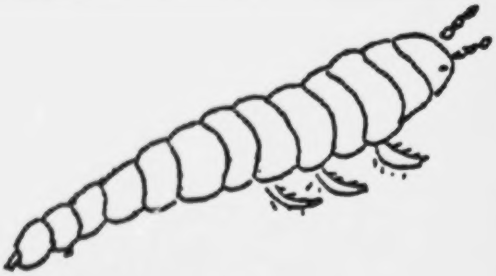
1

(illustrations enlarged 4 x)

The eggs of the grain beetle are about 1/20 of an inch long. A sticky covering causes them to become quickly coated with grains of food. The eggs hatch in about a week.

Compare these eggs to other eggs you know.

2

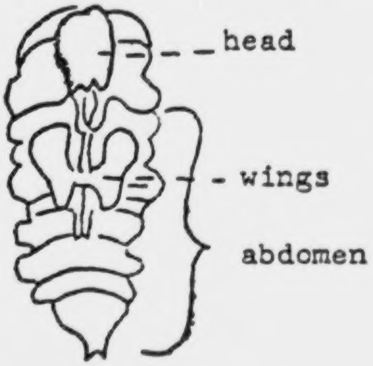


From the egg emerges the beetle larva. It begins to eat immediately and soon it becomes too large for its hard skin. Thus, the larva sheds its skin. This occurs many times.

The larva is a yellowish-brown color.

Do all mealworms have the same number of segments?

3

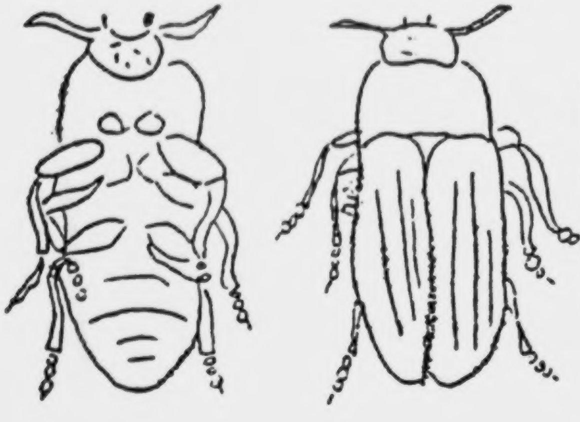


After about five months, the mealworm larva is fully grown and changes into a pupa, the inactive stage. This stage lasts about one week depending on temperature and available moisture.

The pupa is whitish in color.

What is taking place during the pupa stage?

4



When the adult beetle appears from the pupa it is white. Then it turns brown and finally black.

The adult beetle is unable to use its wings for flight.

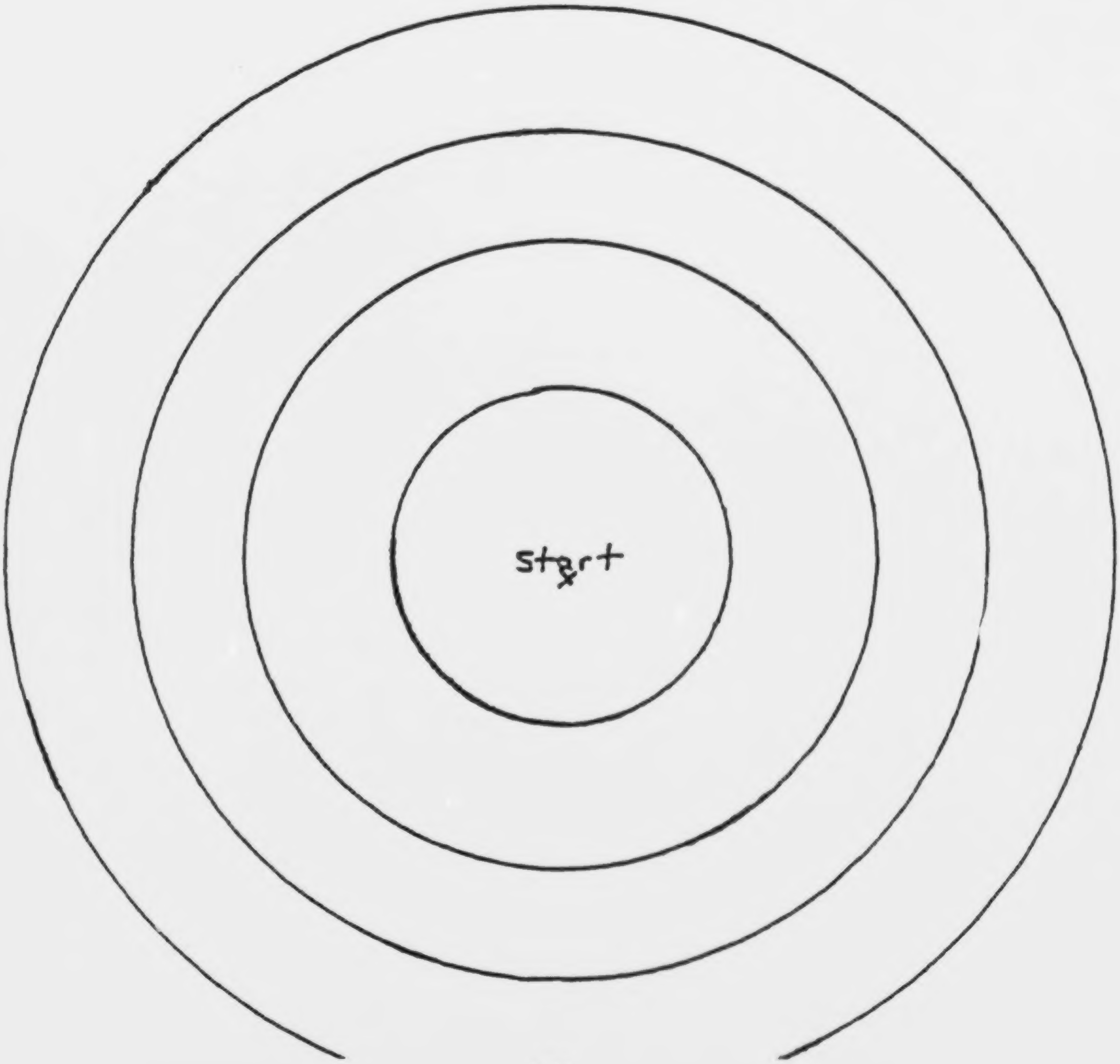
Adults usually live only a few months. At this time, the female lays her eggs, and the cycle begins again.

Do you think mealworms would make interesting pets? Why?

HOW FAR DOES YOUR MEALWORM GO?

NAME ______________________________

1. Put the mealworm on start.
2. Count to 25 slowly.
3. Make an X where the mealworm stops.
4. Now put the mealworm on start again.
5. Mark the spot where it stops this time with a O.
6. Measure how many centimeters the mealworm moved.
   Trial #1__________
   Trial #2__________
7. How far do you think it will move next time? Try it.
9. Were you right?_________
10. Try it 3 more times. ______________ ______________ ______________



APPENDIX B-3

CAN YOU FIND?

This is a good activity as an introduction to outdoor work and also for getting students to know each other better.

Procedure: Distribute the sheet. Ask the students to read the questions. After that have them interview each other to find the answers. Set a time limit. Then ask the students to report what they have found.

CAN YOU FIND -

(Write your answer after each question.)

1. someone whose favorite color is the same as yours? What natural object is the same color?
2. someone who has seen a chickadee?
3. someone who at some time has held a snake?
4. someone who considers himself not too "old" to roll down a hill?
5. someone who has grown an avocado seed?
6. someone who likes the same season of the year as you? Do you like the season for the same reasons?
7. someone who has seen the sun rise?
8. someone who has gone on a night hike?
9. someone who has heard a frog?
10. someone who has visited a national wildlife refuge?
11. someone who has recently looked at the clouds and took the time to imagine seeing the shapes of different things?
12. someone who has put up a bird feeder or bird house?

CAN YOU FIND Someone Who -

(Talk to your classmates. Find someone who can answer each question. Write that person's name next to the question.)

1. has been on a tugboat?

2. has seen plankton under a microscope?

3. has been on two islands in the East River?

4. has seen a tide marker?

5. has visited a weather ship?

6. has seen a garbage scow?

7. has traveled on the Circle Line?

8. knows where the nearest estuary is?

9. has eaten sea weed?

10. has watched a gull soaring?

11. knows the color of a baby gull?

12. has collected a razor clam?

13. has seen tracks of gulls in the sand?

14. has watched the sun set at the beach?

15. has observed Hell Gate and knows where and what it is?

CAN YOU FIND......?

(This is a type of scavanger hunt)

1. Something that is your favorite color.
2. Something that never changes.
3. Something with more than four legs.
4. Something yellow.
5. The oldest thing you can find.
6. Something that always changes.
7. The most beautiful thing you can find.
8. The hardest thing you can find.
9. Something that makes you smile.
10. The home of an animal.
11. Something that needs sun in order to live.
12. Something prickly or fuzzy.
13. Something in the park that makes you happy.
14. Something in the park that makes you unhappy.

APPENDIX B-4

LIFESTYLE SURVEY FORM

NAME:____________________________

DATE:____________________________

Place an X in the column which best describes your feeling about giving up a particular item.

ELECTRICAL APPLICANCE OR ITEM	DO NOT HAVE	VERY EASILY	WITH SOME DIFFICULTY	IMPOSSIBLE
Radio				
Stereo (record player)				
Air Conditioner				
Electric Fan				
Clock				
Freezer				
Typewriter				
Copy Machine				
Power Tools				
Refrigerator				
Iron				
Dishwasher				
Electric Mixer				
Doorbell				
Electric Stove				
Hair Dryer (or hair blower)				
Elevator				
Toaster				
Electric Blanket				
Blender				
Lights				
Clothes Washer				
Telephone				
Sewing Machine				
Electric Curlers (or curling iron)				
Color T.V.				
Black & White T.V.				
Electric Toothbrush				

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